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## Annotated bibliography on steel sheet pile structures, March 1967

P. K. Krugmann

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Earth Pressures and Retaining Structures

ANNOTATED BIBLIOGRAPHY  
ON STEEL SHEET  
PILE STRUCTURES

FRITZ ENGINEERING  
LABORATORY LIBRARY

by  
Peter K. Krugmann  
John Boschuk, Jr.  
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Fritz Engineering Laboratory Report No. 342.1

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ANNOTATED BIBLIOGRAPHY ON STEEL SHEET PILE STRUCTURES

by

Peter K. Krugmann

John Boschuk, Jr.

H. Y. Fang

This work has been carried out as a part of an investigation sponsored by the American Iron and Steel Institute..

Fritz Engineering Laboratory  
Department of Civil Engineering  
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Bethlehem, Pennsylvania

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ABSTRACT

At the present date no source is available which lists systematically the literature on design, theory, and installation of sheet piling structures. The purpose of this report is therefore to aid in locating sufficient material on these subjects.

The emphasis in the selection of titles has been on the last two decades and about two thirds of all listed references have been published after 1950. Full bibliographical data for all references together with short abstracts for more than one half of the listed titles have been compiled.

## 1. INTRODUCTION

At the present date no source is available that lists the feasible references about sheet piles in the form of a literature survey. It is the purpose of this report to give a bibliography that can aid engineers in locating sufficient material on the different aspects related to theory, design, and installation of steel sheet piling structures. This summary does not intend to provide methods of calculation and design. However, it will list references from which one can obtain the required information.

The general composition of this report is to give in different chapters a short description of a specific aspect, by name:

Forms and Section Properties of Steel Sheet Piles

Theories and Design Procedures; Field and Laboratory Tests

Installation and Removal; Durability and Corrosion

At the end of each chapter the reader will find a list of references, the selection of which has been guided by the title. Those references marked by an asterisk have short abstracts in alphabetical order at the end of the report.

## 2. FORMS AND SECTION PROPERTIES OF STEEL SHEET PILES

A sheetpiling wall consists of a series of sheet piles driven side by side into the ground thus forming a continuous vertical wall that is to retain chiefly lateral earth and water pressures, but which can also transmit vertical forces to the ground. Commonly used materials for sheet piles are wood, concrete, and steel. However, this report deals only with the latter type, beginning with a short description of available shapes and followed by some remarks about obtainable information of section properties.

### 2.1 Straight Web Piles

These piles are designed for structures where the prime consideration of design is in the tensile strength of the interlock and not the bending strength of the section. These piles can be obtained in many weights and thicknesses depending on the driving and corrosion conditions present in the area of construction. Straight web sections are used in all applications where the interlocks are subjected to tension stresses, that is, principally in cellular construction. Piling of this type is rated by its interlock tensile strength.

## 2.2 Arch Web Piling

Arch web piles have cross-sections somewhat U-shaped and are designed essentially for applications in which a combination of beam strength and interlock tightness is required. This piling should never be used where excessive interlock tensile forces are present because there will be a tendency for the U-shape to stretch out or flatten. This piling is not rated according to interlock tensile strength but on bending strength and is used for wall or bulkhead types of structures where bending is of primary consideration.

## 2.3 Z-Piling

The Z-piling is of higher beam strength than arch web piling and offers the maximum economy sheet piling can have. Of all the sections produced by manufacturers this piling has the highest ratio of beam strength to weight. American producers of this piling have changed the interlock system from the thumb and finger system used in other shapes to the ball and socket interlock used in the Z-sections. The Z-piling has little interlock tensile strength and its properties are only predicated on its high bending strength.

## 2.4 Interlocks

American manufacturers of sheet piling produce two types of interlocks. All straight web and arch web sections have interlocks known as the thumb and finger type. This form of connection provides continuous contact throughout the longitudinal section and promotes



both strength and water tightness. This type of construction also allows the pile to swing or rotate about the interlock. This rotational ability of the system is essential in all circular and cellular constructions. The Z-piling affords the least resistance to driving and has little or no ability to swing about its ball and socket form of interlock. Construction with Z-piling is limited to straight walls with high bending moments.

### 2.5 Section Properties

The section properties of steel sheet piling are published by all steel companies that produce these sections. Among the forms for publication of these properties are books, booklets, and pamphlets. The standard set of section properties is:

1. Width
2. Thickness
3. Depth
4. Weight per foot or per square foot
5. Area of a single section
6. Moment of inertia
7. Section modulus for a single section and per foot  
of wall

Other information often contained in these brochures describes typical joints; methods of bolting and welding; types of corners and butts; accessories such as tie rods, wales, and anchorages. The more complete publications also include methods of calculation and design and give illustrations and case histories of completed and partially completed installations.

REFERENCES\*

- Arbed-Belval: Sheet Piling Arbed-Belval  
Edition 1964, Luxembourg  
(U. S. Agents: Amerlux Steel Products Corporation, New York)
- Armco Metal Sheeting  
Armco Drainage Products Association
- Bethlehem Steel: Typical Installations of Bethlehem Steel  
Sheet Piling,  
Bethlehem Steel Corporation, Booklet 127-B,  
Bethlehem, Pennsylvania, 1959
- Bethlehem Steel Sheet Piling  
Bethlehem Steel Corporation, Catalog 443-C,  
Bethlehem, Pennsylvania, 1966
- Bethlehem Steel Z-Type Steel Sheet Piling  
Bethlehem Steel Corporation, Bethlehem, Pennsylvania
- B.S.P.: The B.S.P. (British Steel-Piling) Pocket Book  
London, 1963
- Caine Steel Company: Corrugated Steel Sheet Piling  
Caine Steel Company
- Frodingham Steel-Piling  
The British Steel Piling Company, Ltd.,  
London, 1964
- \*Hoesch - Steel Sheet Piling  
Lieberman Waelchli and Company  
15-19 West 37th Street, New York, New York 10018
- \*Hoesch: Die Stahlspondwand „Hoesch“  
Hoesch Aktiengesellschaft Westfalenhütte,  
Dortmund, 5. Auflage 1962
- Inland Steel Sheet Piling and Accessories  
Inland Steel Company  
Chicago, Illinois, 1965

---

\* Denotes those references for which short abstracts  
are compiled at the end of the report.

\*Krupp: Stahlspondwände und Stahlrammpfähle, Bauart Krupp  
Ausgabe 1962, Hütten- und Bergwerke Rheinhausen A.G.,  
Rheinhausen, 1962

\*Lackner, E.  
Spundwände, Grundbau-Taschenbuch, Band 1,  
2. Auflage, Wilh. Ernst & Sohn, Berlin 1966

\*Larssen-Handbuch  
Dortmund-Hörder Hüttenunion A.G.,  
Dortmund, Ausgabe 1960

Larssen: Profile und Profiltafeln  
Dortmund-Hörder Hüttenunion A.G.,  
Dortmund, Ausgabe 1964

\*Peiner Kastenspondwand  
Ilseder Hütte, Peine, 3. Auflage 1960

\*Rombas Steel Sheet Piling  
Sidélor Usine de Rombas, Steel Sheet Piling Central Office;  
2, Rue de Penthievre, Paris 1964

Sidélor: Palplanches Métalliques Rombas,  
Metz 1964

Steel Sheet Pilings  
Steel Products Manual, AISI, Section 5,  
New York, June 1948

United States Steel Sheet Piling Catalog  
United States Steel Corporation, ADUCO 25009-60,  
525 William Penn Place  
Pittsburgh, Pennsylvania, 1960

United States Steel Mariner Steel Sheet and H-Piling  
United States Steel Corporation, ADUSS 25023  
525 William Penn Place  
Pittsburgh, Pennsylvania, May 1964

United States Steel Sheet Piling  
United States Steel Corporation, ADUSS 25-2369, Seventh Printing,  
525 William Penn Place  
Pittsburgh, Pennsylvania, 1967

Weirton Steel Sheet Piling  
Weirton Steel Company

Yawata: Steel Products  
Yawata, 1963

### 3. THEORIES AND DESIGN PROCEDURES; FIELD AND LABORATORY TESTS

Sheet piling walls may be used as temporary structures (cofferdams or cut-off walls) or as permanent structures (retaining walls, wharves, lock and dock walls, shore protection structures and piers).

The purpose of these constructions is mainly to resist horizontal forces, such as earth and water pressures. These loads are carried to the ground by that part of the bulkhead which is driven into the soil (cantilever sheet piling) or by the embedment in the ground and additional anchors at one or several levels (anchored walls). The type of support depends on the height of the wall and the magnitude of forces. These in turn are affected by the soil properties (unit weight, cohesion, angle of inner friction), the water level behind and in front of the bulkhead, and the flexibility of the sheet piling. The upper support may consist of struts or anchors whose forces are transmitted to the entire wall by means of wales on the front or on the back side of the structure.

Although anchored bulkheads were already in use in pre-Roman times, it appears that no attempt was made to design them on the basis of earth pressure computations until about 1910. The investigation of this problem began, assuming an earth pressure distribution according to Rankine's or Coulomb's theory. However, both solutions only give

reliable earth pressure values if the wall yields laterally either by sliding or by rotation about the bottom of the wall. In contrast an anchored sheet piling bulkhead bulges or yields considerably more at a point between the tie rod level and the dredge line than at other portions of the wall.

Because of this fact many tests - both in the field and laboratory - have been carried out during the last three decades and numerous procedures have been developed. For example, the "elastic line", the "elastic beam", the "equivalent beam", and a method for designing against the ultimate total failure of the structure have been formulated.

The references listed in the following give information on performed tests, calculations, and design procedures, types of sheet pile structures, case histories, and anchorages.

REFERENCES\*

Abouleid, A.-F.

Beitrag zur Berechnung einer in lockerem Sand gerammten  
zweifach verankerten Spundwand,  
Mitteilungen des Instituts für Wasserwirtschaft,  
Grundbau und Wasserbau der Technischen Hochschule Stuttgart,  
Stuttgart, 1963

\*Abouleid, A.-F.

Die zweifach verankerte Spundwand,  
Erddruckermittlung und Bemessung,  
Die Bautechnik 40, Heft 12, p. 415, 1963

\*Acuff, J. T. and S. M. Johnson

Inclusion of Old Bulkhead in New Structure Saves  
Time and Money,  
Engineering News-Record, November 15, 1962

Agatz, A.

Die Vertiefung von Kaimauern und Spundwänden ohne  
zusätzliche Verstärkung,  
Hansa 87, Nr. 37, p. 1157, 1950

\*Agatz, A. and E. Lackner

Spundwandbauwerke, Schleicher: Taschenbuch für  
Bauingenieure, Vol. II, pp. 116-141,  
Springer-Verlag, Berlin/Göttingen/Heidelberg, 1955

Anderson, P.

Substructure Analysis and Design,  
2nd Edition, Ronald Press Company, New York, 1956

Annen, G.

Zur Rammtiefe von Spundwänden,  
Der Bauingenieur 39, Heft 9, p. 361, 1964

\*Ayers, J. R. and R. C. Stokes

The Design of Flexible Bulkheads,  
ASCE Transactions, Paper No. 2676, Vol. 119, p. 373, 1954

Baes, L.

"Belval P" Flat Sheet Piles for Cellular Structures,  
Papers presented to the Second International Conference  
on Soil Mechanics and Foundation Engineering,  
Rotterdam, 1948

---

\* Denotes those references for which short abstracts  
are compiled at the end of the report.

- Baumann, P.  
Analysis of Sheet Pile Bulkheads,  
ASCE Transactions, Vol. 100, pp. 707-797, 1935
- \*Bazant, Z.  
Calculation of Stability Against Seepage Failure by  
Using an Electronic Digital Computer,  
Proceedings, International Conference on Soil  
Mechanics and Foundation Engineering, pp. 215-223,  
Budapest, 1963 (in German)
- Bethlehem Steel: Typical Installations of Bethlehem Steel  
Sheet Piling,  
Bethlehem Steel Corporation, Booklet 127-B,  
Bethlehem, Pennsylvania, 1959
- \*Bjerrum, L., J. Brinch Hansen, and R. A. Sevaldson  
Geotechnical Investigations for Quay Structures in Horten,  
Norwegian Geotechnical Institute, Publication 28
- \*Bjerrum, L., T. C. Kenney, and B. Kjaernsli  
Measuring Instruments for Strutted Excavating,  
ASCE Proceedings, Journal of the Soil Mechanics and  
Foundation Division, Vol. 91, No. SM1, pp. 111-141,  
January 1965
- Blum, H.  
Einspannungsverhältnisse bei Bohlwerken,  
Wilh. Ernst & Sohn, Berlin, 1931
- Blum, H.  
Beitrag zur Berechnung von Spundwandfangedämmen,  
Wilh. Ernst & Sohn, Berlin, 1944
- \*Blum, H.  
Beitrag zur Berechnung von Bohlwerken,  
Die Bautechnik 27, Heft 2, pp. 45-52, 1950
- \*Blum, H.  
Beitrag zur Berechnung von Bohlwerken unter  
besonderer Berücksichtigung der Wandverformung,  
Wilh. Ernst & Sohn, Berlin, 1951
- \*Blum, H.  
Fangedämme, Grundbau-Taschenbuch, Band 1  
2. Auflage, p. 495, Wilh. Ernst & Sohn, Berlin, 1966
- \*Boyer, W. C. and H. M. Lummis  
Design Curves for Anchored Steel Sheet Piling,  
ASCE Transactions, Vol. 119, p. 639, 1954

- \*Brinch Hansen, J.  
Earth Pressure Calculation,  
Danish Technical Press, Copenhagen, 1953
- Brinch Hansen, J.  
Development of the Christiani and Nielsen Wharf Type,  
Christiani and Nielsen, Bulletin 56, Copenhagen, 1956
- Brinch Hansen, J. and H. Lundgren  
Hauptprobleme der Bodenmechanik,  
Springer-Verlag, Berlin, 1960
- Brinch Hansen, J.  
Spundwandberechnungen nach dem Traglastverfahren,  
Internationaler Baugrundkursus 1961,  
Mitteilungen aus dem Institut für Verkehrswasserbau,  
Grundbau und Bodenmechanik der Technischen Hochschule  
Aachen, Heft 25, p. 171, Aachen, 1962
- \*Brinch Hansen, J.  
Simplified Stress Determination in Soils,  
Danish Geotechnical Institute, Bulletin No. 20,  
pp. 5-7, Copenhagen, 1966
- Briske, R.  
Anwendung von Erddruckumlagerungen bei Spundwandbauwerken,  
Die Bautechnik 34, Heft 7, p. 264 and Heft 10, p. 376, 1957
- Briske, R.  
Erddruckverlagerung bei Spundwandbauwerken,  
2. Auflage, Wilh. Ernst & Sohn, Berlin, 1957
- Browzin, B. S.  
Upon the Deflection and Strength of Anchored Bulkheads,  
Proceedings, 2nd International Conference on Soil Mechanics  
and Foundation Engineering, Vol. 3, p. 302, Rotterdam, 1948
- Bruns, T. C.  
Z-Pile Cofferdam for New Orleans' Tallest Building,  
Civil Engineering, p. 68, May 1961
- Buchholz, W.  
Erdwiderstand auf Ankerplatten,  
Jahrbuch Hafenbautechn. Gesellschaft 12, p. 300,  
Berlin, 1932
- Buchholz, W. und H. Petermann  
Berechnungsverfahren für Ankerplatten und -wände,  
Der Bauingenieur 16, p. 227, 1935
- \*Bültmann, W.  
Zur Berechnung von Bohlwänden,  
Die Bautechnik 41, Heft 4, p. 132, 1964



Casagrande, A.  
Neue Ergebnisse der Untergrundforschung,  
Schriftenreihe der "Strasse", 3, Berlin, 1936

\*Cooling, L. F.  
Second Rankine Lecture: Field Measurements in Soil Mechanics,  
Geotechnique, Vol. 12, No. 3, pp. 77-104, London, June 1962

\*Corps of Engineers  
Shore Protection Planning and Design,  
Technical Report 4, Dept. of the Army, Corps of Engineers,  
Office of the Chief of Engineers, Beach Erosion Board,  
June 1954

\*Cummings, E. M.  
Application of Soil Mechanics to Engineering Structures,  
Bethlehem Steel Corporation, Sales Department,  
Piling Division, Bethlehem, Pennsylvania

Cummings, E. M.  
Cellular Cofferdams and Docks,  
ASCE Proc. Paper No. 1366, Vol. 83, No. WW3,  
September 1957

Cummings, E. M.  
Mixed Soils Require Five Designs for Ore Dock Reconstruction,  
Civil Engineering, p. 62, November 1957

Davidenkoff, R. N.  
About the Calculation of Anchored Bulkheads with Fixed  
Earth Support,  
2nd International Conference on Soil Mechanics and Foundation  
Engineering, Vol. V, pp. 122-124, Rotterdam, 1948

\*DiBiagio, E. and L. Bjerrum  
Earth Pressure Measurements in a Trench Excavated in Stiff  
Marine Clay,  
Proceedings of the 4th International Conference on  
Soil Mechanics and Foundation Engineering,  
Vol. 11, p. 196, London, 1957

\*Dismuke, T. D.  
Method of Determining Stress in Loaded Steel Billet Tie Backs,  
Instrument Society of America, Reprint No. 34-TC-61, June 1961

\*Duke, C. M.  
Field Study of a Sheet Pile Bulkhead,  
ASCE, Transactions Paper No. 2572, Vol. 118, pp. 1131-1196,  
with discussion, pp. 1157-1163, 1953

Dunham, C. W.  
Foundation of Structures,  
McGraw-Hill, New York, 1962

\*Edelman, Joustra, Koppejan, van der Veen, van Weele:  
Comparative Sheet Pile Calculations,  
Brussels Conference on Earth Pressure Problems,  
Vol. II, p. 71, Brussels, 1958

\*Empfehlungen des Arbeitsausschusses "Ufereinfassungen"  
3. Aufl., Wilh. Ernst & Sohn, Berlin, 1964

Feld, J.  
Lateral Earth Pressure,  
ASCE Transactions, Vol. 86, pp. 1448-1505, 1923

\*Feld, J.  
Arrested Steel Sheet Pile Bulkhead Failure -  
Cause and Correction,  
Proceedings, 3rd International Conference on Soil  
Mechanics and Foundation Engineering, Vol. II, p. 167,  
Zurich, 1953

Finke, G.  
Verankerung von Stahlspundwänden durch horizontale  
Betonortspfähle mit verstärktem Fuss,  
Hansa 87, Nr. 37, p. 1176, 1950

Fröhlich, O. K.  
Bodenmechanische Gesichtspunkte für die Berechnung  
von Fangedämmen,  
Die Bautechnik 18, p. 543, 1940

\*Gantke, F.  
Vereinfachungen in Rowe's Berechnung verankerter  
Spundwände,  
Die Bautechnik 41, Heft 6, pp. 201-203, 1964

\*Gerber, E.  
Untersuchungen über die Druckverteilung im örtlich  
belasteten Sand,  
Zurich, 1929

Grasshoff, H.  
Die Berechnung der Einspannkräfte an Dalben  
und freistehenden Spundwänden,  
Vorträge der Baugrundtagung 1962 in Essen, p. 151  
Deutsche Gesellschaft für Erd-und Grundbau e. V.,  
Essen, 1962

\*Gray, H. and K. Nair  
A Note on the Stability of Soil Subject to Seepage  
Forces Adjacent to a Sheet Pile,  
Geotechnique 17, No. 2, pp. 136-144, June 1967

Gruhle, H. D.  
Verformungsmessungen an den Spundwänden der  
Schleuse Friedrichsfeld,  
Die Bautechnik 36, Heft 4, p. 128, 1959

- \*Hakman, P. A. and W. M. Buser  
Bulkhead Test Program at Port of Toledo, Ohio,  
ASCE Journal of the Soil Mechanics and Foundation  
Division, Proceedings Paper 3176, June 1962
- Hedde, P.  
Beitrag zur Berechnung eingespannter Spundwände,  
Die Bautechnik 15, Heft 51, p. 659, 1937
- \*Henderson, R. P. and M. A. J. Matich  
Use of Slope Indicator to Measure Movements in  
Earth Slopes and Bulkheads,  
ASTM, STP 322, Field Testing of Soils, pp. 166-186, 1963
- \*Hoesch - Steel Sheet Piling  
Lieberman Waelchli and Company, Inc.  
15-19 West 37th Street, New York, New York 10018
- \*Hoesch: Die Stahlspundwand „Hoesch“  
Hoesch Aktiengesellschaft Westfalenhütte,  
Dortmund, 5. Auflage 1962
- Hoffmann, H.  
Nomographische Berechnung doppelt verankerter Bohlwände,  
Die Bautechnik 35, Heft 2, p. 59, 1958
- \*Hueckel, S.  
Model Tests on Anchoring Capacity of Vertical and  
Inclined Plates,  
Proceedings of the 4th International Conference on  
Soil Mechanics and Foundation Engineering, Vol. II,  
p. 203, London, 1957
- \*Ireland, H. O.  
Design and Construction of Retaining Walls,  
Proceedings, Soil Mechanics Lecture Series on Design  
of Structures to Resist Earth Pressures, pp. 51-90,  
Chicago, 1964
- \*Irwin-Childs, F. and I. J. A. H. Hartman  
Karachi Harbour - East Wharves, Reconstruction of Quay,  
Proceedings, The Institution of Civil Engineers,  
Vol. 21, London, 1962
- Ishiguro, K.  
Design and Construction of Steel Sheet Piling,  
1963 (in Japanese)
- Jacoby, E.  
Grundsätzliches zur Berechnung von Spundwänden,  
Die Bautechnik 19, Heft 8, p. 88, 1941

\*Jasper and Ringheim

Steel Sheet Piling Studies,  
3rd International Conference on Soil Mechanics and  
Foundation Engineering, Vol. II, p. 264, Zurich, 1953

\*Jelinek, R.

Remarks on the Safety of Cofferdams and Sheet Pile  
Anchorage,  
5th International Conference on Soil Mechanics and  
Foundation Engineering, Vol. III, pp. 330-332, Paris, 1961

\*Jelinek, R. and H. Ostermayer

Zur Berechnung von Fangedämmen und verankerten  
Stützwänden,  
Die Bautechnik 44, Heft 5, pp. 167-171 and  
Heft 6, pp. 203-207, 1967

Jenne, A.

Vereinfachung für die Berechnung einfach verankerter  
Spundwände,  
Die Bautechnik 35, Heft 3, p. 93, 1958

\*Jessberger, L.

Theorie und Praxis eines neuzeitlichen Verankerungs-  
verfahrens,  
Die Bautechnik 40, Heft 7, p. 226, 1963

\*Johnson, S. M.

Field Study of a Cellular Bulkhead,  
ASCE Journal of the Soil Mechanics and Foundation  
Engineering Division, Vol. 88, No. SM-1, February 1962

\*Jumikis, A. R.

Mechanics of Soils,  
D. Van Nostrand Co., Inc., Princeton, New Jersey, 1964

Kassel, F. L.

Penetration of Sheet Pile Retaining Walls,  
Civil Engineering and Public Works Review,  
Vol. 39, No. 455, pp. 108-111, London, 1944

\*Kézdi, A.

Erddrucktheorien,  
Springer-Verlag, Berlin, 1962

Knop, E.

Vorspannung der Verankerung von Stützwänden,  
Bautechnik-Archiv, Heft 8, p. 60,  
Wilh. Ernst & Sohn, Berlin, 1952

Kranz, E.

Über die Verankerung von Spundwänden,  
Wilh. Ernst & Sohn, 2. Aufl., Berlin, 1953

Krey, H.

Erddruck, Erdwiderstand und Tragfähigkeit des Baugrundes,  
5. Aufl., Wilh. Ernst & Sohn, Berlin, 1936

\*Krupp: Stahlspundwände und Stahlrammpfähle, Bauart Krupp,  
Ausgabe 1962, Hütten- und Bergwerke Rheinhausen A. G.,  
Rheinhausen, 1962

Krynine, D. P.

Soil Mechanics,  
McGraw-Hill Book Company, Inc.,  
pp. 317-327, New York, 1947

Kyle and Kapp

A Flexible Bulkhead for New York Harbor,  
Proceedings, 4th International Conference on Soil  
Mechanics and Foundation Engineering,  
Vol. II, p. 218, also Vol. III, p. 233, London, 1957

Lackner, E.

Berechnung mehrfach gestützter Spundwände,  
3. Aufl., Wilh. Ernst & Sohn, Berlin 1950

\*Lackner, E.

Spundwände, Grundbau-Taschenbuch, Band 1,  
2. Auflage, Wilh. Ernst & Sohn, Berlin, 1966

\*Lacroix, Y. H.

Design and Construction of a Deep Cutoff,  
Ph. D. Thesis, University of Illinois, 1961  
(Univ. Micr. Serv. 62-633)

Larssen: Entwurfsgrundlagen,

Dortmund-Hörder Hüttenunion A. G.,  
Dortmund, Ausgabe 1959

\*Larssen-Handbuch,

Dortmund-Hörder Hüttenunion A. G.,  
Dortmund, Ausgabe 1960

\*Lawson, L. D.

Seabees Give Technical Assistance in Chile -  
U. S. Navy Assists in Rebuilding Wharf Destroyed by  
Earthquake,  
ASCE, Civil Engineering, pp. 47-49, February 1965

Lea, N. D.

Performance of a Steel Sheet Piling Bulkhead,  
Proceedings, 3rd International Conference on Soil Mechanics  
and Foundation Engineering,  
Vol. II, p. 180, Zurich, 1953

\*Lechner, W.

Kurventafeln für die zeitsparende Berechnung von  
verankerten und unverankerten Spundwänden,  
Die Bautechnik 44, Heft 4, p. 131, 1967

Lee, D. H. and C. E. Riches

Location of Anchor Blocks in Sheet Pile and Similar Walls,  
Civil Engineering and Public Works Review, Vol. 44,  
No. 520, p. 576, London, October 1949

Lehmann, H.

Die Verteilung des Erdangriffs an einer oben  
drehbar gelagerten Wand,  
Die Bautechnik 20, Heft 31/32, p. 273, 1942

Leimdörfer, P.

Some Views on the Selection of Steel Sheet Piling,  
17th International Navigation Congress,  
SI-C1, p. 159, Lisbon, 1949

Leonards, G. A.

Foundation Engineering,  
McGraw-Hill Book Company, New York, 1962

\*Lincoln, F. L.

Reconstruction of Dry Dock No. 3 at the Portsmouth  
Naval Shipyard,  
Boston Society of Civil Engineers, Journal, pp. 256-265,  
October 1963

\*Lohmeyer, E.

Die Spannungen in der Larssenwand,  
Die Bautechnik 15, Heft 53, p. 699, 1937

Loos, W. und H. Breth

Modellversuche über Biegebeanspruchung von Pfählen  
und Spundwänden,  
Der Bauingenieur 24, Heft 9, p. 264, 1949

Loos, W.

Verankerte Spundwände,  
Der Bauingenieur 27, Heft 9, p. 350, 1952

Lorenz, H.

Zur Tragfähigkeit starrer Spundwände und Mastgründungen,  
Bautechnik-Archiv, Heft 8, p. 79,  
Wilh. Ernst & Sohn, Berlin, 1952

\*McDermott, J. F.

All-Steel Abutments for Highway Bridges,  
ASCE, Civil Engineering, pp. 54-56, February 1963

McNamee, J.

Seepage into a Sheeted Excavation,  
Geotechnique, Vol. I, pp. 229-241, London, 1949

\*Mackintosh, I. B.

Cofferdamming the Columbia River for the John Day Dam,  
Civil Engineering and Public Works Review,  
pp. 1264-1268, October 1963

\*Marsland, A.

Model Experiments to Study the Influence of Seepage  
on the Stability of a Sheeted Excavation in Sand,  
Geotechnique, Vol. III, p. 223, London, 1952/1953

\*Martin, G. P. and W. J. Shirley

Design and Construction of No. 2 Dry Dock for Vickers-  
Armstrongs (Ship-builders) Ltd., Hebburn, Co., Durham,  
Proceedings, The Institution of Civil Engineers, pp. 513-548,  
December 1963

\*Matich, M. A. J., R. P. Henderson, and D. B. Oates

Performance Measurements on Two New Anchored Bulkheads,  
Canadian Geotechnical Journal, Vol. I, No. 3. pp. 167-178,  
July 1964

\*Mead, C. F.

Measure of Earth Pressure on a Sheetpile Breast-work,  
4th Australia and New Zealand Conference on Soil  
Mechanics and Foundation Engineering, Adelaide, 1963

Mecke, W.

Der Erdangriff an einer im unteren Teil nachgiebigen Wand,  
Dissertation, Hannover, 1939

\*Ménard, L. and G. Bourdon

Calculation of Lateral Supports - A New Method  
Including True Conditions of Embedment,  
Sols-Soils, No. 12, p. 18038, March 1965  
(in French with English summary)

\*Ménard, L., G. Bourdon, and A. Houy

Experimental Study of the Fixity of a Diaphragm with  
Respect to the Soil Characteristics,  
Sols-Soils, No. 9, Vol. III, pp. 11-41, June 1964  
(in French with abstracts in English, German, and  
Spanish)

Minikin, R. R.

Retaining Walls of Flexible Sheet piling,  
Civil Engineering and Public Works Review,  
Vol. 43, No. 506, pp. 396-399, London, August 1948

Molitor, D. A.

Wave Pressures on Sea Walls and Breakwaters,  
ASCE Transactions, Vol. 100, Paper No. 1913, p. 984, 1935

Morgan, H. D.

The Design of Wharves on Soft Ground,  
The Institution of Civil Engineers, Paper No. 5393,  
p. 22, London, March 1954

\*Müller, P.

Erddruckmessungen bei mechanisch verdichteter  
Hinterfüllung von Stützkörpern,  
Die Bautechnik 17, Heft 13, pp. 195-203, 1939

Ohde, J.

Zur Erddrucklehre,  
Die Bautechnik, Vol. 25, p. 121, 1948, Vol. 26, p. 360,  
1949, Vol. 27, p. 111, 1950, Vol. 28, p. 297, 1951,  
Vol. 29, pp. 31/219/315, 1952

Ohde, J.

Zur Theorie des Erddruckes unter besonderer  
Berücksichtigung der Erddruckverteilung,  
Die Bautechnik 16, pp. 150/176/241/331/480/570/753, 1938

\*Oien and Kjell

An Earth Pressure Cell for Use on Sheet Piles - Oslo Subway,  
Proceedings, Brussels Conference on Earth Pressure Problems,  
Vol. II, p. 118, Brussels, 1958

Ovesen, N. K.

Cellular Cofferdams, Calculation Methods and Model Tests,  
Danish Geotechnical Institute, Bulletin No. 14,  
Copenhagen, 1962

\*Ovesen, N. K.

Anchor Slabs, Calculation Methods and Model Tests,  
Danish Geotechnical Institute, Bulletin No. 16,  
Copenhagen, 1964

Packshaw, S.

Cofferdams,  
Proceedings, The Institution of Civil Engineers,  
February 1962, London, with discussion - January 1963

Packshaw, S.

The Application of Steel Sheet Piling to Engineering  
Construction,  
Civil Engineering and Public Works Review, London,  
December 1932, January 1933

\*Peck, R. B.

Earth Pressure Measurements in Open Cuts, Chicago Subway,  
ASCE Transactions, Vol. 108, pp. 1008-1036, 1943



- Peck, R. B., W. E. Hansen and T. H. Thornburn  
Foundation Engineering,  
John Wiley & Sons, Inc., New York, 1953
- Pennoyer, R. A.  
Design of Sheet-Piling Bulkheads,  
Civil Engineering, Vol. 3, pp. 615-619, November 1933
- Petermann, H.  
Ankerplattenbewegung und -widerstand, Einfluss von  
Lagerungsdichte und Ankerabstand, Massstabgesetz  
für Weg und Kraft,  
Dissertation, Hannover, 1933
- Petermann, H.  
Bewegung und Kraft bei Ankerplatten,  
Der Bauingenieur 14, p. 531, 1933
- \*Petermann, H.  
Schrifttum über Bodenmechanik,  
Forschungsarbeiten aus dem Strassenwesen,  
Neue Folge Heft 10, Kirschbaumverlag, Bielefeld, 1953
- Petermann, H.  
Verankerte Bohlwände, Berechnungsmethoden und Versuche,  
Der Bauingenieur 30, Heft 9, p. 329, 1955
- \*Petermann, H. and W. Börner  
Schrifttum über Bodenmechanik II,  
Forschungsarbeiten aus dem Strassenwesen,  
Heft 32, Kirschbaumverlag, Bielefeld, 1957
- \*Petermann, H. and H. Kühn  
Schrifttum über Bodenmechanik III,  
Forschungsarbeiten aus dem Strassenwesen,  
Heft 46, Kirschbaumverlag, Bielefeld, 1961
- \*Petermann, H. and H. Kühn  
Schrifttum über Bodenmechanik IV,  
Forschungsarbeiten aus dem Strassenwesen,  
Band 63, Kirschbaumverlag, Bad Godesberg, 1965
- \*Piles, Horizontal Piles Brace Cofferdam Wall,  
Engineering News Record, Vol. 160, No. 17, pp. 55-58,  
April 24, 1958
- \*Plummer, F. L. and S. J. Dore  
Soil Mechanics and Foundations,  
Pitman Publishing Corporation, New York, 1940
- Press, H.  
Über die Druckverteilung im Boden hinter Wänden  
verschiedener Art,  
Bautechnik-Archiv, Heft 2, p. 36,  
Wilh. Ernst & Sohn, Berlin, 1948

- \*Richart, Jr. F. E.  
Analysis for Sheet Pile Retaining Walls,  
ASCE Transactions, p. 1113, 1957
- \*Richart, Jr. F. E.  
Anchored Bulkhead Design by Numerical Method,  
ASCE Journal of the Soil Mechanics and Foundation  
Division, February 1960
- Rifaat, J.  
Die Spundwand als Erddruckproblem,  
Dissertation, Mitteilungen des Instituts für  
Baustatik, ETH Zurich, Heft 5, Zurich, 1935
- Rimstad, I. A.  
Zur Bemessung des doppelten Spundwandbauwerkes,  
Dissertation, Berlin, 1940,  
Ingeniörvidenskabelige Skrifter Nr. 4,  
Copenhagen, 1940
- \*Rombas Steel Sheet Piling  
Sidélor Usine de Rombas, Steel Sheet Piling Central Office;  
2, Rue de Penthievre, Paris, 1964
- \*Rowe, P. W.  
Anchored Sheet-Pile Walls,  
Proceedings of the Institution of Civil Engineers,  
Vol. I, pp. 27-70, London, January 1952
- \*Rowe, P. W.  
A Stress-Strain Theory for Cohesionless Soil with  
Applications to Earth Pressures at Rest and Moving Walls,  
Geotechnique, Vol. IV, No. 2, London, June 1954
- Rowe, P. W.  
A Theoretical and Experimental Analysis of Sheet Pile Walls,  
Proceedings of the Institution of Civil Engineers, Vol. 4,  
No. 1, p. 32, London, 1955
- Rowe, P. W.  
The Stability Characteristics of Sheet Pile Walls,  
Structural Engineer, Vol. 34, p. 150, London, 1955
- Rowe, P. W.  
Sheet Pile Walls Encastré at the Anchorage,  
Proceedings of the Institution of Civil Engineers,  
Pt. 1, Paper No. 5990, p. 70, London, 1955
- \*Rowe, P. W.  
Sheet Pile Walls at Failure,  
Proceedings of the Institution of Civil Engineers,  
Vol. 5, Nr. 3, p. 276, Paper No. 6107, London, May 1956

Rowe, P. W.

Present Situation on Retaining Wall Design,  
Structural Engineer, Vol. 34, No. 6, pp. 204-217,  
London, June 1956

\*Rowe, P. W.

Measurements on Sheet Pile Walls Driven into Clay,  
Proceedings, Brussels Conference on Earth Pressure  
Problems, Vol. II, p. 127, Brussels, 1958

\*Rowe, P. W. and A. Briggs

Measurements on Model Strutted Sheet Pile Excavations,  
Proceedings, 5th International Conference on Soil  
Mechanics and Foundation Engineering, Vol. II, pp. 473-478,  
Paris, 1961

\*Schneebeli, G. and R. Cavaill -Coll

Contribution au Calcul de la Stabilit  des  
Bat rdeaux   Double Paroi de Palplanches  
(Contribution to the Stability Analysis of Double-wall  
Sheet Pile Cofferdams),  
Proceedings, 4th International Conference on Soil  
Mechanics and Foundation Engineering, Vol. II, p. 233,  
London, 1957

Sch tte, G. H.

Wirkungen von Form nderungen verankerter Bohlw nde und  
des st tzenden Bodens auf die Verteilung der inneren  
und  usseren Kr fte,  
Dissertation, Hannover, 1940

Sch tte, G. H.

Einspannungsbedingungen verankerter Bohlw nde,  
Der Bauingenieur 22, Heft 19/20, p. 193, 1941

Schultze, E.

Die graphische Statik doppelt verankerter Spundw nde,  
Bauplanung und Bautechnik, Bd. 3, Nr. 6, p. 177, 1949

Schultze, E.

Neue Vorschl ge f r die Berechnung von Spundw nden,  
Die Bautechnik 27, Heft 11, p. 366, 1950

Schultze, E.

Suppressions derri re les murs de Quai, La Houille Blanche,  
Mitteilungen aus dem Institut f r Verkehrswasserbau, Grundbau  
und Bodenmechanik der Technischen Hochschule Aachen, Heft 2,  
Aachen, 1952

\*Schultze, E.

Vergleich von Berechnungsverfahren f r verankerte Spundw nde,  
Der Bauingenieur 33, Heft 4, pp. 163-167, 1958

\*Schultze, E.

Empfehlungen für die Berechnung von Spundwänden in  
der Deutschen Bundesrepublik,  
Proceedings, International Conference on Soil Mechanics  
and Foundation Engineering, p. 87093, Budapest, 1963

\*Seelye, E. E.

Foundation, Design and Practice,  
John Wiley & Sons, Inc., New York, 1956

Seelye, E. E.

Field Practice, Second edition, Vol. III,  
John Wiley & Sons, Inc., New York, 1957

Sheeted Cofferdam Toe into Bedrock

Construction Methods and Equipment, June 1958

Sheeting, New Sheeting Method Saves Time, Money, Material,  
Construction Methods and Equipment, June 1958

Sheet Pile Bulkheads, The Stability of Sheet Pile

Bulkheads, (General report and discussion),  
Proceedings, Brussels Conference on Earth Pressure  
Problems, Vol. III, p. 209, Brussels, 1958

\*Sheet Piles: How to Work with Sheetpiles,

Construction Methods and Equipment, pp. 92-95, December 1962

\*Shinohara, T., T. Tateishi and S. Kitajima

Lateral Resistance of Sheet Pile Cellular Detached  
Pier at Shimizu Harbour,  
Soil and Foundation, Vol. I, No. 1, pp. 35-41,  
April 1960

Shoemaker, P. R.

Steel Sheet Pile Cells Form Bulkhead for Long Beach Harbor,  
ASCE Civil Engineering, September 1950

Skempton, A. W.

Earth Pressure and Stability of Slopes,  
(The Principles and Applications of Soil Mechanics),  
The Institution of Civil Engineers, p. 31, London, 1946

Skempton, A. W.

Earth Pressure, Retaining Walls, Tunnels and Strutted  
Excavations, (General Report),  
Proceedings, 3rd International Conference on Soil  
Mechanics and Foundation Engineering, Session 7,  
p. 354, Zurich, 1953

- \*Sowers, G. F., A. D. Robb, C. H. Mullis, and A. J. Glenn  
The Residual Lateral Pressures Produced by Compacting  
Soils,  
Proceedings, 4th International Conference on Soil  
Mechanics and Foundation Engineering, Vol. II, p. 243,  
London, 1957
- \*Spangler, M. G.  
Horizontal Pressures on Retaining Walls due to  
Concentrated Surface Loads,  
Iowa Engineering Experiment Station, Bulletin 140,  
Iowa City, Iowa
- Spangler, M. G. and J. L. Mickle  
Lateral Pressures on Retaining Walls Due to Backfill  
Surface Loads,  
Highway Research Board, Bulletin 141, pp. 1-18, 1956
- Streck, A.  
Verankerte Spundwände,  
Mitt. Hannov. Hochschulgemeinschaft 16, p. 6, 1935
- Streck, A.  
Spundwandberechnung,  
Mitt. Hannov. Hochschulgemeinschaft 17/18, p. 225, 1937
- Stroyer, J. P. R. N.  
Earth Pressure on Flexible Walls,  
The Institution of Civil Engineers,  
Journal, Vol. I, p. 94, London, November 1935
- \*Swiger, W. F.  
Prestressed Sheet Pile Underpinning,  
ASCE, Civil Engineering, June 1957
- Taylor, D. W.  
Fundamentals of Soil Mechanics,  
John Wiley & Sons, Inc., New York, 1948
- Template Double as Forms, Forms as Cofferdams  
Construction Methods and Equipment, June 1961
- \*Teng, W. C.  
Foundation Design,  
Prentice Hall, Inc., Englewood Cliffs, N. J., 1965
- Tennessee Valley Authority: Cofferdams on Rock,  
Technical Monograph 75, Vol. 1, Tennessee Valley  
Authority, Nashville, Tennessee, 1958
- Terzaghi, K.  
Large Retaining Wall Tests,  
Engineering News-Record, Vol. 112, pp. 136-140, 1934

- Terzaghi, K.  
Distribution of the Lateral Pressure of Sand  
on the Timbering of Cuts,  
Proceedings, International Conference of Soil Mechanics,  
Vol. 1, p. 221, Cambridge, Mass. U. S. A., 1936
- \*Terzaghi, K.  
Anchored Bulkheads,  
Purdue Conference on Soil Mechanics, pp. 259-269,  
September 1940
- Terzaghi, K.  
General Wedge Theory of Earth Pressure,  
ASCE Transactions, Vol. 106, pp. 68-97, 1941
- \*Terzaghi, K.  
Theoretical Soil Mechanics,  
John Wiley & Sons, New York, 1943
- Terzaghi, K.  
Stability and Stiffness of Cellular Cofferdams,  
Proceedings, ASCE, 1945
- \*Terzaghi, K.  
Anchored Bulkheads,  
ASCE Transactions, Vol. 119, pp. 1243-1280,  
with discussion, pp. 1281-1324, 1954
- Terzaghi, K.  
Verankerte Spundwände  
VEB Verlag Technik, Berlin, 1957
- \*Thompson, P. J. and M. A. J. Matich  
The Performance of Some Steel Sheet Pile Bulkheads,  
Proceedings, 15th Canadian Soil Mechanics Conference,  
pp. 80-114, 1961
- Tschebotarioff, G. P. and P. P. Brown  
Lateral Earth Pressure as a Problem of Deformation  
or of Rupture,  
Proceedings, 2nd International Conference on  
Soil Mechanics and Foundation Engineering,  
pp. 81-86, Rotterdam, 1948
- Tschebotarioff, G. P.  
Determination from Bending Strain Measurements  
of the Distribution of Lateral Earth Pressures  
Against Flexible Bulkheads,  
Geotechnique, Vol. I, No. 2, pp. 98-111, London, 1948
- Tschebotarioff, G. P.  
Design of Flexible Anchored Sheet Pile Bulkheads,  
17th International Navigation Congress, SI-C1, p. 51,  
Lisbon, 1949

Tschebotarioff, G. P.

Some Unsolved Problems of Importance for the Design of  
Earth Retaining Structures,  
Permanent International Association of Navigation  
Congress, Bulletin No. 33, 1950

Tschebotarioff, G. P.

Einfluss der „Gewölbebildung“ auf die Erddruckverteilung,,  
Bautechnik-Archiv, Heft 8, S. 33,  
Wilh. Ernst & Sohn, Berlin, 1952

\*Tschebotarioff, G. P.

Soil Mechanics, Foundations, and Earth Structures,  
McGraw-Hill, New York, 1953

\*Tschebotarioff, G. P. and E. R. Ward

Measurements with Wiegmann Inclinator on Five  
Sheet Pile Bulkheads,  
Proceedings, 4th International Conference on Soil  
Mechanics and Foundation Engineering, Vol. II, p. 248,  
London, 1957

Tschebotarioff, G. P., E. Ward, E. DiBiagio, J. Watkins,  
and D. Perrine

Bending Moments by Direct Measurements,  
Engineering News-Record, April 24, 1958

\*Tschebotarioff, G. P.

Certain Features of Lateral Pressure of Soil,  
Highway Research Board, Special Report No. 60,  
pp. 154-162, Washington, D. C., 1960

\*Tschebotarioff, G. P.

Design and Construction of Flexible Retaining Structures,  
Proceedings, Soil Mechanics Lecture Series on Design of  
Structures to Resist Earth Pressures, pp. 35-48, Chicago, 1964

U. S. Army Engineers Manual: Design of Pile Structures and  
Foundations,

Superintendent of Documents,  
U. S. Government Printing Office, Washington, D. C., 20025

U. S. Navy Bureau of Yards and Docks: Soil Mechanics - DM-7,

U. S. Government Printing Office, Washington, D. C., 20025

United States Steel: Design Extracts from Former Publications,

United States Steel Sheet Piling, revised edition, January 1967  
United States Steel Corporation,  
525 William Penn Place  
Pittsburgh, Pennsylvania, 1967

United States Steel Sheet Piling  
United States Steel Corporation, ADUSS 25-2369, 7th Printing,  
525 William Penn Place  
Pittsburgh, Pennsylvania, 1967

\*Verdeyen and Roisin  
Relationships between External Concentrated Load  
Effects and the Characteristics of Flexible  
Bulkheads, (in French)  
Proceedings, 5th International Conference on Soil  
Mechanics and Foundation Engineering, Vol. II, p. 501,  
Paris, 1961

Ward, W. H.  
Techniques for Field Measurement of Deformation and  
Earth Pressures,  
Conference on the Correlation Between Calculated and  
Observed Stresses and Displacements in Structures,  
Institution of Civil Engineers, London, 1955

\*White, A., J. A. Cheney and C. M. Duke  
Field Study of a Cellular Bulkhead,  
ASCE Journal of the Soil Mechanics and Foundation  
Division, Vol. 87, No. SM4, pp. 89-124, August 1961

\*White, E. E.  
Design and Construction of Braced Cuts,  
Proceedings, Soil Mechanics Lecture Series on Design  
of Structures to Resist Earth Pressures, pp. 93-127,  
Chicago, 1964

White, L. and E. A. Prentis  
Cofferdams,  
Columbia University Press, New York, 1950

\*Wiegel, R. L. and R. E. Skjei  
Breaking Wave Force Prediction,  
Proceedings ASCE, Waterways and Harbors Division,  
Vol. 84, pp. 1-14, March 1958

Wiegmann, D.  
Der Erddruck auf verankerte Stahlspundwände,  
festgestellt auf Grund von Verformungsmessungen  
am Bauwerk,  
Dissertation, Hannover, 1953

Wiendieck, K.  
Zur Standsicherheit unverankerter Spundwände,  
Die Bautechnik 39, Heft 11, p. 369, 1962

\*Windels, R.  
Berechnung von Bohlwerken nach dem Traglastverfahren,  
Die Bautechnik 36, Heft 6, p. 212, 1959



\*Wrigley, G. A.

Some Lessons for British Practice?  
Civil Engineering and Public Works Review,  
pp. 1422-1425, November 1963

\*Zweck, H. and Th. Dietrich

Die Berechnung verankerter Spundwände  
in nichtbindigen Böden nach Rowe,  
Mitteilungsblatt der Bundesanstalt für Wasserbau,  
Karlsruhe, Heft 13, 1959

#### 4. INSTALLATION, REMOVAL; DURABILITY AND CORROSION

##### 4.1 Installation

Sheet piles are installed by a driving device known as a pile hammer. This hammer may be suspended from the boom of a crawler crane, supported on a large frame called the pile driver or carried on a barge for construction in water.

Several types of hammers are in use and each of which has different sizes. The hammer types are:

- Drop hammer
- Single-acting hammer
- Double-acting hammer
- Diesel hammer
- Vibratory hammer

The choice of the hammer type depends mainly on the driving depth, the subsurface conditions and the dimensions of the sheet pile.

##### 4.2 Removal

If the completed structure lies in or near at the water, the sheet piles used for the cofferdam normally are not extracted in order to protect the foundation against seepage. In these cases they are cut at a certain depth.

Other walls are to be removed after completion of the foundation. This removal can be done in minor cases (small penetration depth and a limited number of piles) with skrew jacks, hydraulic jacks, hoists and the like. In bigger jobs, special extractors should be used, which pull out the pile while simultaneously decreasing the shearing forces between soil and pile by short blows. In some cases, vibratory hammers give good results.

#### 4.3 Durability and Corrosion

Sheet piling walls can be constructed on dry land, in fresh water, or in sea water. The rate of corrosion and the durability differ considerably between the locations. The principal factors affecting the rate of deterioration are:

1. The type of structure (for example: harbour bulkheads, beach bulkheads, groins)
2. The geographical location
3. The type of soil
4. The exposure to aggressive waters.

To protect a steel sheet piling wall against excessive corrosion, the following methods may be used:

1. Additional thickness in excess of the sectional area as required by the strength;
2. Removal of the corrosive soil (only economical for shallow depth);

3. Concrete encasement of the endangered parts;
4. Painting with a coat of tar, bituminous paint, or other protective material;
5. Cathodic protection - this may be done either by supplying a low-voltage direct current to an iron or graphite anode buried near the piles or by depressing the potential of the piles by grounding them, or by a combination of both.

In the listed references information can be found on pile driving devices and extractors, on installation and removal procedures, on measurements made at sheet piling walls under different conditions in order to determine the rate of deterioration and on protective methods.

REFERENCES\*

Baxmann, F. und W. Rosendahl  
Rammen, Ziehen, Felsbeseitigung,  
Vulkan-Verlag Dr. W. Classen, Essen, 1964

Beaudry, L.  
Quay Wall Design and Construction,  
Eng. J. (Canada) 14, p. 394, 1931

Bjerrum, L.  
Norwegian Experience with Steel Pile Foundations to Rock,  
Journal Boston Soc. Civil Engineers, 44, No. 3, p. 155, 1957

\*Boggs, E. W.  
Vibratory Driver Successful for Sheetpile Cells,  
ASCE, Civil Engineering, pp. 58-60, April 1964

Brouillette, C. V. and A. E. Hanna  
Corrosion Survey of Steel Sheet Piling,  
Tech. Report 097, U. S. Naval Civil Engineering Laboratory,  
Port Hueneme, California, December 1960

B.S.P.: Pile Driving Equipment,  
British Steel Piling Co., Ltd.

Chellis, R. D.  
Pile Driving Handbook,  
Pitman Publishing Company, 1944

\*Chellis, R. D.  
Pile Foundations, 2nd Edition  
McGraw-Hill Book Company, New York, 1961

Colling, G.  
Das Arbeiten mit Stahlspundbohlen,  
Acier, Stahl, Steel 29, Heft 5, p. 244, 1964

Foster  
Foster Vibro Driver/Extractor,  
L. B. Foster Company, Performance Data,  
Catalog 39, Pittsburgh, Pa., 1966

---

\* Denotes those references for which short abstracts  
are compiled at the end of the report.

Foundation Equipment Corporation  
Delmag Diesel Pile Hammers,  
The Foundation Equipment Corporation,  
Newcomerstown, Ohio

Gallaway, B. M.  
A Report on Some Factors Affecting the Life of  
Steel Pilings in the Texas Gulf Coast Area,  
Texas Transportation Institute, College Station,  
Texas, October 1955

Greulich, A. A.  
Extracted Steel H-Piles Found in Good Condition,  
Engineering News-Record, 145, No. 8, p. 41,  
August 1950

\*Hammer, Vibratory Hammer from France Drives Piles Fast,  
Construction and Equipment, September 1962

\*Hoesch - Steel Sheet Piling  
Lieberman Waelchli and Company, Inc.  
15-19 West 37th Street, New York, New York 10018

\*Hoesch: Die Stahlspundwand „Hoesch“  
Hoesch Aktiengesellschaft Westfalenhütte,  
Dortmund, 5. Auflage 1962

Holthaus, C.  
Untersuchungen über den Angriff von Spundwandeseisen in Fluss-  
und Seewasser,  
Archiv für das Eisenhüttenwesen 8, Heft 9, p. 379, 1934/35

Hool, G. A. and W. S. Kinne  
Foundations, Abutments and Footings, 2nd Edition,  
McGraw-Hill Book Company, Inc., New York, 1953

\*Illiger  
Korrosionsuntersuchungen an Stahlspundwänden  
des Rhein-Herne-Kanals und des Dortmund-Ems-Kanals,  
Die Bautechnik 33, Heft 6, pp. 190-195, 1956

\*Ishiguro, K. and Y. Hatano  
Strength of Sheet Pile in Driving  
(in Japanese with English summary)  
The Fuji Iron and Steel Company, Ltd.

Kluth, P.  
Rammgeräte,  
Bauwirtschaft 6, No. 37, pp. 62-64 and No. 46,  
pp. 77-81, 1952

\*Krupp: Stahlpundwände und Stahlrammpfähle, Bauart Krupp,  
Ausgabe 1962, Hütten- und Bergwerke Rheinhausen A. G.,  
Rheinhausen, 1962

Larssen: Rammen und Ziehen,  
Dortmund-Hörder Hüttenunion, A. G.,  
Dortmund, Ausgabe 1952

\*Larssen-Handbuch,  
Dortmund-Hörder Hüttenunion A. G.,  
Dortmund, Ausgabe 1960

Leimdörfer, P.  
The Useful Life of Steel Sheet-Piling,  
International Navigation Congress, SII-C1,  
p. 99, Rome, 1953

Link-Belt Speeder Company  
Diesel Pile Hammer - Models 190/520  
Link-Belt Speeder Company,  
Cedar Rapids, Iowa, Catalog No. 2844-8-66

Link-Belt Speeder Company  
Link-Belt 440 Diesel Pile Hammer,  
Link-Belt Speeder Company,  
Cedar Rapids, Iowa, Catalog No. 3901-9-66

Lipp, M. N.  
Some Data on Beach Protection Works,  
Civil Engineering, 6, No. 5, p. 291, 1936

McKiernan-Terry Corporation  
Double-Acting Pile Hammers and Extractors,  
McKiernan-Terry Corporation, Bulletins 58R and 58A

McKiernan-Terry Corporation  
Diesel Pile Hammers,  
McKiernan-Terry Corporation, Bulletin 67

Mason, J. G. and A. L. Ogle  
Steel Pile Foundations in Nebraska,  
Civil Engineering 2, No. 9, p. 533, 1932

Medvedev, S. R.  
The Use of Vibrators for Driving Steel Sheet Piling,  
Civil Engineering and Public Works Review,  
Vol. 48, No. 559, pp. 61-62, January 1953

Mississippi Valley Equipment Company  
Specifications on Vulcan Pile Hammers and Extractors,  
Mississippi Valley Equipment Company, Form G-2,  
1908 Railway Exchange Building, St. Louis, Missouri

Rayner, A. C. and C. W. Ross  
Durability of Steel Sheet Pilings in Shore Structures,  
Techn. Memo. No. 12, Beach Erosion Board,  
Corps of Engineers, U. S. Army, February 1952

Rayner, A. C.  
Life of Steel Sheetpile Structures in Atlantic  
Coastal Structures,  
Proceedings, 3rd Conference on Coastal Engineering,  
pp. 209-216, Cambridge, Massachusetts, 1952

Romanoff, M.  
Underground Corrosion,  
National Bureau of Standards Circular 579,  
U. S. Government Printing Office,  
Washington, D. C. 20025, 1957

\*Romanoff, M.  
Corrosion of Steel Pilings in Soils,  
National Bureau of Standards Monograph 58,  
U. S. Government Printing Office,  
Washington, D. C. 20025, October 1962

\*Rombas Steel Sheet Piling,  
Sidélor Usine de Rombas,  
Steel Sheet Piling Central Office,  
2, Rue de Penthievre, Paris, 1964

Ross, C. W.  
Deterioration of Steel Sheet Pile Groins at  
Palm Beach, Florida  
Corrosion 5, No. 10, p. 339, 1949

\*Schenck, W.  
Rammen und Ziehen,  
Grundbau-Taschenbuch, Band 1, 2. Auflage,  
p. 716, Wilh. Ernst & Sohn, Berlin, 1966

Schmidt, H. E. G.  
Neuere Rammen und ihre Betriebsergebnisse,  
Der Tiefbau 11, pp. 917-927, 1964

Schwerdtfeger, W. J.  
Laboratory Measurements of the Corrosion of  
Ferrous Metals in Soils,  
J. Research National Bureau of Standards 50,  
p. 329, 1953

\*Sheetpiles, How to Work with Sheetpiles,  
Construction Methods and Equipment, November 1962



\*Sheetpiling, Huge Guide-Traveler Speeds Driving  
of 65 Miles of Sheetpiling,  
Engineering News Record, Vol. 143, No. 19,  
pp. 39-41, November 1949

Sheetpiling, Life of Steel Sheet Piling,  
Iron Age 129, No. 23, p. 1247, June 1932

Skipp, B. O.  
Corrosion and Site Investigation,  
Corrosion Technol. 8, No. 9, p. 269,  
September 1961

\*Stüdemann, G.  
Korrosionsschutzmassnahmen bei Stahlpundwänden,  
Die Bautechnik 43, pp. 329-338, 1966

\*Teng, W. C.  
Foundation Design,  
Prentice Hall, Inc., Englewood Cliffs, N. J., 1965

Union Iron Works: Union Pile Hammers,  
Union Iron Works, Catalog 184

United States Steel Protection of Piling in Marine Environments,  
United States Steel Corporation, ADUCO-25003-58,  
525 William Penn Place,  
Pittsburgh, Pennsylvania, 1958

Vulcan Iron Works  
Portable Pile Hammer,  
Vulcan Iron Works, Bulletin 30

Vulcan Iron Works  
Drop Pile Hammers,  
Vulcan Iron Works, Bulletin 66-F

Vulcan Iron Works  
Differential-Acting Pile Hammer, Open Type,  
Vulcan Iron Works, Bulletin 70-E

Vulcan Iron Works  
Pile Extractors,  
Vulcan Iron Works, Bulletin 71-D

Wollin, G.  
Korrosion im Grund- und Wasserbau,  
Die Bautechnik 40, Heft 2, pp. 37-41, 1963

5. ABSTRACTS

Abouleid, A.-F.

Die zweifach verankerte Spundwand, Erddruckermittlung  
und Bemessung,  
Die Bautechnik 40, Heft 12, pp. 415-421, 1963

Model Tests with a double-anchored sheet pile wall retaining granular soil of different densities are described. The influence of anchor yield, surcharge and penetration depth on the distribution of the active earth pressure is investigated and as a result a proposal for the earth pressure distribution is made.

Acuff, J. T. and S. M. Johnson

Inclusion of Old Bulkhead in New Structure Saves Time  
and Money,  
Engineering News-Record, November 15, 1962

An old, deteriorated pier has been repaired by installing a new line of sheet piling 18 to 21 ft. outside the existing wall and tying the new wall back to the old one with 2 inch  $\emptyset$  tie rods. Typical cross-section and connection details are presented.

Agatz, A. and E. Lackner

Spundwandbauwerke, Schleicher: Taschenbuch für  
Bauingenieure, Vol. II, pp. 116-141,  
Springer-Verlag, Berlin/Göttingen/Heidelberg, 1955

This reference gives tables with section properties of German steel sheet piles. It also describes calculation methods for two types of end conditions: simply supported at the top and bottom and fixed at the bottom and simply supported at the top. Moreover some statements are given about cellular cofferdams and anchorages of sheet piling walls.

Ayers, J. R. and R. C. Stokes

The Design of Flexible Bulkheads,  
ASCE Transactions, Paper No. 2676, Vol. 119, p. 373, 1954

This paper presents a description of the design and construction procedures followed by the Bureau of Yards and Docks, United States Department of the Navy, for varying site and soil conditions, together with methods for reducing pressures, proper construction sequence, and practical rules which are axiomatic for bulkhead design.

Bazant, Z.

Calculation of Stability Against Seepage Failure by Using an Electronic Digital Computer, Proceedings, International Conference on Soil Mechanics and Foundation Engineering, pp. 215-223, Budapest, 1963 (in German)

Diagrams for the calculation of the stability against seepage failures (piping, heave) behind bulkheads, sheet piling, and other retaining structures are given. The method is based on sliding circle theory and the calculations have been carried out on a digital computer. A design example is included.

Bjerrum, L., J. Brinch Hansen, and R. A. Sevaldson  
Geotechnical Investigations for Quay Structures in Horten,  
Norwegian Geotechnical Institute, Publication 28

Sheet pile calculations using Brinch Hansen's theories lead to a more economical solution than other methods.

Bjerrum, L., T. C. Kenney, and B. Kjaernsli  
Measuring Instruments for Strutted Excavating,  
ASCE Proceedings, Journal of the Soil Mechanics and Foundation Division, Vol. 91, No. SMI, pp. 111-141, January 1965

A description of the instruments and techniques used in Norway to measure strut loads, earth and water pressures and movements at different excavations in both soft and stiff-fissured clays, as well as information concerning cost, accuracy, and reliability of these instruments is presented.

Blum, H.

Beitrag zur Berechnung von Bohlwerken.  
Die Bautechnik 27, Heft 2, p. 45, 1950

Equations and nomograms for the calculation of sheet piling walls are given from which the penetration depth, the anchor pull, and the bending moments can be determined. Five different types of support are considered. Also included are examples and those values which are necessary for plotting the nomograms.

Blum, H.

Beitrag zur Berechnung von Bohlwerken unter besonderer Berücksichtigung der Wandverformung,  
Wilh. Ernst & Sohn, Berlin, 1951

This reference gives the influence of the flexibility of a sheetpile wall on the maximum bending moment, using the theory of subgrade reaction.

Blum, H.

Fangedämme, Grundbau-Taschenbuch, Band 1  
2. Auflage, pp. 495-509,  
Wilh. Ernst & Sohn, Berlin, 1966

The author gives a short description of box-type, cellular and concrete cofferdams, the assembling procedures and the calculations necessary for dimensioning such structures. Moreover two examples with interesting construction details are included.

Boggs, E. W.

Vibratory Driver Successful for Sheetpile Cells,  
ASCE, Civil Engineering, pp. 58-60, April 1964

A wharf in Lake Erie, Pa. has been constructed of 40 sheet pile cells driven in saturated silty sand, through dense silt to bearing in hard glacial till on bedrock at 42-65 ft. depth. The sheets were driven in 12 or 17 ft. long runs using a template with changeable curved side. Pile driving with differential acting steam hammers proved too slow although considerable jetting was used. Changing to a vibratory hammer (4.5 tons, 840-1100 cycles/min. at 0.375 in. to 0.5 in. amplitude) clamped hydraulically to the sheets doubled the driving speed. Typical driving records and other details are presented graphically.

Boyer, W. C. and H. M. Lummis

Design Curves for Anchored Steel Sheet Piling,  
ASCE Transactions, Vol. 119, p. 639, 1954

These curves are based on Rankine's theory and are destined for preliminary design computations. This reference also gives the complete theoretical derivations. Comments by leading authorities.

Brinch Hansen, J.

Earth Pressure Calculation,  
Danish Technical Press, Copenhagen, 1953

This book discusses all the methods of accepted earth pressure analysis up to 1953. The author analyzes each method and discusses the assumptions each is predicted. Informative and complete.

Brinch Hansen, J.

Simplified Stress Determination in Soils,  
Danish Geotechnical Institute, Bulletin No. 20,  
pp. 5-7, Copenhagen, 1966

A stress-strain relationship is developed to solve the problem of the vertical and horizontal movements of any given point of the surface of a mass of soil subjected to known horizontal and vertical loads. Formulas are developed and explained which provide rough agreement with observed measurements.

Bültmann, W.

Zur Berechnung von Bohlwänden,  
Die Bautechnik 41, Heft 4, pp. 132-139, 1964

Derivations, tables, and graphs are given for the determination of the penetration depth required for sheet piling walls. Different types of support are considered. The earth pressure is assumed to have a trapezoidal shape behind the wall (active earth pressure and water pressure) and a triangular shape in front of the wall (passive earth pressure). Examples are given to show the influence of necessary safety factors.

Chellis, R. D.

Pile Foundations, 2nd Edition  
McGraw-Hill Book Company, New York, 1961

This reference is dedicated to the theory, design, and practice of pile structures. The text has complete information on pile-driving analysis, hammer speeds, strokes and driving stresses, driving equipment, selection of pile and selection of driving method, caisson types, deterioration and preservation of piles, failure of piles, and methods of extraction.

Cooling, L. F.

Second Rankine Lecture: Field Measurements in Soil Mechanics,  
Geotechnique, Vol. 12, No. 3, pp. 77-104, London, June 1962

A series of measurements were made of earth pressures, forces, stresses, and displacements in a large anchored sheetpile dock wall. The measurements were made on a section 35 ft. long and anchored with six tie rods; the load in each rod was measured by vibrating-wire strain gages. The fitting of the instruments was carried out in the laboratory and the sheet piles were later transported to the site and driven into the construction.

#### Corps of Engineers

Shore Protection Planning and Design,  
Technical Report 4, Dept. of the Army, Corps of Engineers  
Office of the Chief of Engineers, Beach Erosion Board,  
June 1954

This reference contains an extensive bibliography and a  
glossary of terms.

#### Cummings, E. M.

Application of Soil Mechanics to Engineering Structures,  
Bethlehem Steel Corporation, Sales Department,  
Piling Division, Bethlehem, Pennsylvania

An excellent source and guide for the design of sheet  
pile structures.

#### DiBiagio, E. and L. Bjerrum

Earth Pressure Measurements in a Trench Excavated in Stiff  
Marine Clay,  
Proceedings of the 4th International Conference on Soil  
Mechanics and Foundation Engineering, Vol. II, p. 196,  
London, 1957

This paper describes earth pressure measurements made in  
a braced experimental trench excavated in the stiff  
fissured crust of the Norwegian marine clay. Horizontal  
and vertical deformations of the soil mass were recorded.  
In addition, pore pressure piezometers were installed to  
measure changes in pore water pressures. Soil properties,  
measured strut loads, and comparisons to calculated values  
are given.

#### Dismuke, T. D.

Method of Determining Stress in Loaded Steel Billet Tie Backs,  
Instrument Society of America, Reprint No. 34-TC-61, June 1961

Reviews the methods used to determine the stresses by  
measuring localized strain changes induced by drilling  
a hole through the billet.

#### Duke, C. M.

Field Study of a Sheet Pile Bulkhead,  
ASCE, Transactions Paper No. 2572, Vol. 118, pp. 1131-1196,  
1953, with discussion, pp. 1157-1163

Analysis and results of a hydraulic filled Long Beach,  
California bulkhead. Lateral pressures and stresses on  
all components of the structure. This analysis includes  
pore pressure studies.

Edelman, Joustra, Koppejan, van der Veen, van Weele:  
Comparative Sheet Pile Calculations,  
Brussels Conference on Earth Pressure Problems,  
Vol. II, p. 71, Brussels, 1958

Five different methods of sheetpile calculations are compared in order to develop Dutch code rules. Limitations of Tschebotarioff's, Schütte's, Rowe's, Blum's and Danish Rules methods are given.

Empfehlungen des Arbeitsausschusses "Ufereinfassungen"  
3. Aufl., Wilh. Ernst & Sohn, Berlin, 1964

This reference gives in the form of a building code information on calculation assumptions (earth pressures, water pressures, ship pull) allowable stresses and construction details of sheet piling bulkheads.

Feld, J.  
Arrested Steel Sheet Pile Bulkhead Failure - Cause and Correction,  
Proceedings, 3rd International Conference on Soil Mechanics and Foundation Engineering, Vol. II, p. 167, Zurich, 1953

Failure of an anchored sheetpile bulkhead due to overloading, corrected by driving additional anchor piles and cables and partially unloading the bulkhead.

Gantke, F.  
Vereinfachungen in Rowe's Berechnung verankerter Spundwände,  
Die Bautechnik 41, Heft 6, pp. 201-203, 1964

The author proposes a simplification of Rowe's method which reduces the amount of computational work. The procedure is illustrated by an example.

Gerber, E.  
Untersuchungen über die Druckverteilung im örtlich belasteten Sand,  
Zurich, 1929

The author determined in model tests the intensity and distribution of the lateral earth pressure. The back-fill consisted of clean, uniform river sand with a grain size between 0.2 and 1.5 mm. The lateral support was practically rigid. The lateral pressures caused by a line load were measured by means of pressure cells arranged in vertical rows.



Gray, H. and K. Nair

A Note on the Stability of Soil Subject to Seepage Forces Adjacent to a Sheet Pile,  
Geotechnique 17, No. 2, pp. 136-144, June 1967

In this note an approximate but very convenient method for analyzing the stability of soil adjacent to a sheet piling against seepage forces is presented. The errors introduced by the approximation are discussed. Graphs facilitating the computation and estimation of errors are presented. A solved example is presented to illustrate the method. The method is based upon a principle analogous to that of St. Venant in elasticity coupled with simple analytic solutions of the Laplace equation.

Hakman, P. A. and W. M. Buser

Bulkhead Test Program at Port of Toledo, Ohio,  
ASCE Journal of the Soil Mechanics and Foundation Division, Proceedings paper 3176, June 1962

38 ft. tall bulkhead instrumented with slope-indicator, strain gages, and displacement markers. Instrument details presented. Observations indicate fair agreement with Tschebotarioff's equivalent beam method although the actual stresses were smaller than the computed.

Hammer, Vibratory Hammer from France Drives Piles Fast,  
Construction and Equipment, September 1962

Sheetpiles for a cofferdam have been driven quickly and efficiently with a French vibratory hammer. Two electric motors, through a roller-chain drive, turn a series of shafts filled with eccentric weights that vibrate the piles. Hydraulic jaw connection between pile and hammer.

Henderson, R. P. and M. A. J. Matich

Use of Slope Indicator to Measure Movements in Earth Slopes and Bulkheads,  
ASTM, STP 322, Field Testing of Soils, pp. 166-186, 1963

The Wilson tiltmeter, which works in a grooved plastic casing, is described and its use for detecting ground movements and as a precautionary measure is illustrated by detailed movement vs. depth diagrams for three high earth slopes and five steel pile bulkheads. Typical cross-sections. Accurate conversion of tiltmeter readings on sheet piling to bending moment require tiltmeter observations of the pile profile as driven. In the discussion G. A. Reti presents a tiltmeter with automatic recording features.

#### Hoesch - Steel Sheet Piling

Lieberman Waelchli and Company, Inc.

15-19 West 37th Street, New York, New York 10018

This pamphlet includes standard sections and section properties, examples for riveted corners, junctions, box piling and rolled corners. Corrections for eccentricity of loaded walls are discussed as well as pile driving and extraction. Also design and calculation examples are given, followed by pictures of executed constructions.

#### Hoesch: Die Stahlspundwand „Hoesch“

Hoesch Aktiengesellschaft Westfalenhütte,

Dortmund, 5. Auflage 1962

This reference gives a short historical review of the development of steel sheet piles, section properties of Hoesch straight web and Z-piles, examples for corners, butts and pile clusters, construction details such as wales and anchorages, driving devices, calculation examples and case histories.

#### Hueckel, S.

Model Tests on Anchoring Capacity of Vertical and Inclined Plates,

Proceedings of the 4th International Conference on Soil Mechanics and Foundation Engineering, Vol. II, p. 203, London, 1957

The paper deals with model tests carried out for the determination of anchoring capacity of vertical and inclined plates embedded in beach sand. The form of sliding wedge, the influence of inclination of plates and of distance between the plates is discussed.

#### Illiger

Korrosionsuntersuchungen an Stahlspundwänden des Rhein-Herne-Kanals und des Dortmund-Ems-Kanals,

Die Bautechnik 33, Heft 6, pp. 190-195, 1956

Measurements at steel sheet piles in fresh water showed much smaller corrosion than comparable piles in sea water. From the obtained results may be concluded that corrosion is not to be considered when dimensioning bulkheads in fresh water.

Ireland, H. O.

Design and Construction of Retaining Walls,  
Proceedings, Soil Mechanics Lecture Series on Design  
of Structures to Resist Earth Pressures, pp. 51-90,  
Chicago, 1964

The author discusses theories of retaining wall design and comments on their adequacy or inadequacy; he also gives illustrative examples of unsatisfactory walls with specific cases, in which is shown that clay back-fill is by far the most notorious.

Irwin-Childs, F. and I. J. A. H. Hartman

Karachi Harbour - East Wharves, Reconstruction of Quay,  
Proceedings, The Institution of Civil Engineers,  
Vol. 21, London, 1962

In this reference design and construction of an anchored bulkhead with prestressed king piles are described. The piles have a sheeted face of concrete curtain slabs. High-tensile wire-cable anchors tie the concrete capping beam to deadmen at 130 feet distance. The deadmen capacity was tested by prestressing the anchors.

Ishiguro, K. and Y. Hatano

Strength of Sheet Pile in Driving  
(in Japanese with English summary)  
The Fuji Iron and Steel Company, Ltd.

For determining the maximum sheetpile driving length tests were performed, the results of which give information whether sheetpile driving is possible or not for a given project.

Jasper and Ringheim

Steel Sheet Piling Studies,  
3rd International Conference on Soil Mechanics and  
Foundation Engineering, Vol. II, p. 264, Zurich, 1953

Study of the effectiveness of steel sheeting as cutoff wall in earth dam. Equations for flow of water through sheeting.

Jelinek, R.

Remarks on the Safety of Cofferdams and Sheet  
Pile Anchorages,  
5th International Conference on Soil Mechanics  
and Foundation Engineering, Vol. III, pp. 330-332,  
Paris, 1961

Graphical methods (based on logarithmic spiral failure  
surfaces) for determining the minimum resistance of  
earthfilled cofferdams and sheetpile anchorages.  
Variation of the theoretical failure surface inclination  
with changes in the cofferdam width to height ratio are  
shown to be small.

Jelinek, R. and H. Ostermayer

Zur Berechnung von Fangedämmen und verankerten Stützwänden,  
Die Bautechnik 44, Heft 5, pp. 167-171 and Heft 6, pp. 203-207,  
1967

This reference describes a method to design thin  
earthfilled cofferdams and sheetpiling walls with  
short anchors. The calculation is based on the  
assumption of logarithmic spirals, which is shown  
to be in line with model test results.

Jessberger, L.

Theorie und Praxis eines neuzeitlichen Verankerungs-  
verfahrens,  
Die Bautechnik 40, Heft 7, p. 226, 1963

The author describes an injection anchorage whose  
theoretical principles are based on numerous loading  
tests. The installation procedure is described and  
illustrated by some completed structures. For  
common types of soils a table of allowable anchor  
pull is included.

Johnson, S. M.

Field Study of a Cellular Bulkhead,  
ASCE Journal of the Soil Mechanics and Foundation  
Engineering Division, Vol. 88, No. SM-1, February 1962

Detailed field measurements of movements and strains  
in steel sheetpile cells. An extensive analysis with  
much theory.

Jumikis, A. R.

Mechanics of Soils,

D. Van Nostrand Co., Inc., Princeton, New Jersey, 1964

After the discussion of earth pressure distributions in non-cohesive and in frictional-cohesive soils the author derives the principles for the design of cantilever sheet pile walls loaded with a concentrated horizontal force and for the design of cantilever and anchored sheet pile walls loaded with earth and water pressure.

Kézdi, Á.

Erddrucktheorien,

Springer-Verlag, Berlin, 1962

Four groups of earth pressure theories are considered: methods using the theory of elasticity or plasticity, methods using equilibrium and kinematic compatibility conditions, and variational principles. Although the treatment of sheet pile bulkheads is short, the given material shows clearly the basic assumptions and limitations of different earth pressure theories.

Krupp: Stahlspundwände und Stahlrammpfähle, Bauart Krupp, Ausgabe 1962, Hütten- und Bergwerke Rheinhausen A. G., Rheinhausen, 1962

This booklet includes section properties, types of driving caps and clamps, methods of driving and extraction. Other items included are the properties of sections, lengths, welding, holes, chisel points, reinforcing, butt joints, bolts and concrete filling of boxes. Methods of wall design with example problems are also included.

Lackner, E.

Spundwände, Grundbau-Taschenbuch, Band 1,

2. Auflage, Wilh. Ernst & Sohn, Berlin, 1966

This reference gives section properties of English, French, German, Luxemburg, and U. S. American piles as well as calculation methods after Blum, Streck, Tschebotarioff, Ohde, Rowe, Brinch Hansen, and Lackner. Also examples of built sheetpile walls and of anchorage systems are given. Good reference list.

Lacroix, Y. H.

Design and Construction of a Deep Cutoff,  
Ph.D. Thesis, University of Illinois, 1961  
(Univ. Micr. Serv. 62-633)

A detailed record of design, construction and performance of the deep cutoff installed at Mission Dam, B. C., Canada, which is founded on very compressible clay underlain by alluvial deposits. Details of grout curtain of unprecedented size and a sheetpile cutoff installed in the dam core to withstand very large differential settlements. An old sheetpile wall buried 50 ft. was breached and a groove was carved in the granite at 100 ft. depth.

Larssen-Handbuch,

Dortmund-Hörder Hüttenunion A. G.,  
Dortmund, Ausgabe 1960

This book includes section properties of Larssen steel sheet piles, different wall combinations, solutions for joints and corners, driving devices and directions for the execution of construction. Other topics covered are design and calculation of steel sheetpiling walls as well as examples of built wharves, piers, cofferdams, and pile foundations.

Lawson, L. D.

Seabees Give Technical Assistance in Chile - U. S. Navy  
Assists in Rebuilding Wharf Destroyed by Earthquake,  
ASCE, Civil Engineering, pp. 47-49, February 1965

A concrete gravity quay wall in Chile founded on marine clay and backfilled with beach sand failed during the 1960 earthquake due to liquefaction of the backfill. The U. S. Navy assisted in the construction of a replacement wall consisting of a bulkhead of ZP-38 sheetpiling anchored with steel rods to concrete deadmen. The unorthodox construction conditions and techniques, necessitated by the lack of supplies and skilled tradesmen, are outlined.

Lechner, W.

Kurventafeln für die zeitsparende Berechnung von  
verankerten und unverankerten Spundwänden,  
Die Bautechnik 44, Heft 4, p. 131, 1967

For the case of homogenous soil diagrams are given for determination of the required penetration depth, the tie rod force and the maximum bending moment in cantilever and simply anchored sheetpiling walls.

Lincoln, F. L.

Reconstruction of Dry Dock No. 3 at the Portsmouth Naval Shipyard,  
Boston Society of Civil Engineers, Journal, pp. 256-265,  
October 1963

A 17 ft. deep dry dock with walls of circular sheet pile cells was enlarged to 37 ft. depth by installing an interior sheet pile bulkhead penetrating soft blue clay and glacial till to bedrock. To preserve the stability of the original cells the new sheeting was braced across the cofferdam and stage excavation was used. The sheeting was designed to act as partial reinforcement of the new concrete wall. The heavy Z-sheet piling was reinforced during construction by driving 12" W-120 lb. soldier beams in the valleys between adjoining sheet piles.

Lohmeyer, E.

Die Spannungen in der Larssenwand,  
Die Bautechnik 15, Heft 53, pp. 699-708, 1937

This reference gives information about the interlock friction in Larssen sheet piles. Development of 75% of full section modulus by adding sand into the interlocks.

McDermott, J. F.

All-Steel Abutments for Highway Bridges,  
ASCE, Civil Engineering, pp. 54-56, February 1963

Design and cost data advocating the use of steel H-piles and sheetpiling to support superstructure and retain earth fill at bridge abutments. 30% - 50% cost savings realized as compared to reinforced concrete abutments. References are presented in support of the contention that corrosion is not a problem if scouring and pollution are prevented.

Mackintosh, I. B.

Cofferdamming the Columbia River for the John Day Dam,  
Civil Engineering and Public Works Review, pp. 1264-1268,  
October 1963

This article gives a description of the rockfill dike and the cellular steel sheetpile cofferdams used during the construction of the John Day Dam on the Columbia River. Design features, gradation characteristics of embankment materials, construction procedures, and effectiveness of the completed cofferdams are described. Well illustrated.

Marsland, A.

Model Experiments to Study the Influence of Seepage on the Stability of a Sheeted Excavation in Sand,  
Geotechnique, Vol. III, p. 223, London, 1952/1953

This article describes model experiments performed at the B. R. S. to determine the type of failure occurring in strutted sheeted excavations. The results are discussed and tentative suggestions for design are put forward.

Martin, G. P. and W. J. Shirley

Design and Construction of No. 2 Dry Dock for Vickers-Armstrongs (Ship-builders) Ltd., Hebburn, Co., Durham,  
Proceedings, The Institution of Civil Engineers,  
pp. 513-548, December 1963

This dock was founded on layers of glacial clays, silts and sands and boulder clay underlain by sand and gravel on bedrock. High artesian pressures were resisted by a heavy dock structure (24' slab thickness). The 44' tall sheet walls were retained by anchors with the tie rods placed through slag fill by a horizontal piledriving rig. When the walls yielded, they were strengthened by steel trusses and the addition of raking pile anchorages. Blows in cofferdam sections were repaired by clay fill blankets.

Matich, M. A. J., R. P. Henderson, and D. B. Oates

Performance Measurements on Two New Anchored Bulkheads,  
Canadian Geotechnical Journal, Vol. I, No. 3, pp. 167-178,  
July 1964

Field observations of stresses and deflections in steel sheet-pile anchored bulkheads are compared with computed bending moments and tie rod stresses. Fair agreement between observed and calculated bending moments was obtained at one site, but comparison at the other site was not possible due to difficulties in evaluating the friction in the sheet pile interlocks. The observations are presented in graphical form.

Mead, C. F.

Measure of Earth Pressure on a Sheetpile Breast-work,  
4th Australia and New Zealand Conference on Soil  
Mechanics and Foundation Engineering, Adelaide, 1963

In Auckland, N. Z., steel sheetpiles were driven into sandstone with scoria backfill. Earth pressures were measured with ten Goldback-type pressure cells located at varying depth three feet behind the sheet piles. Results comply with those of Duke but not with other investigators. This may be due in part to erroneous readings. Diagrams of measured pressures are shown.



Ménard, L. and G. Bourdon

Calculation of Lateral Supports - A New Method Including True Conditions of Embedment,  
Sols-Soils, No. 12, p. 18038, March 1965  
(in French with English summary)

This article gives a method for obtaining the shear forces and moments in tied bulkheads considering the type of ties, the flexibility of the wall, the coefficient of subgrade reaction and passive and active pressure variations with amount of wall yield. The method is illustrated by two numerical examples.

Ménard, L., G. Bourdon, and A. Houy

Experimental Study of the Fixity of a Diaphragm with Respect to the Soil Characteristics,  
Sols-Soils, No. 9, Vol. III, pp. 11-41, June 1964  
(in French with abstracts in English, German, and Spanish)

The authors present the results of experiments (utilizing pressuremeter testing) to verify a method for determining the horizontal subgrade reaction, the passive resistance, displacements and deformations of steel sheetpile or concrete diaphragm walls as a function of the applied forces on the walls. Theoretical and experimental values agreed within 20%.

Müller, P.

Erddruckmessungen bei mechanisch verdichteter Hinterfüllung von Stützkörpern,  
Die Bautechnik 17, Heft 13, pp. 195-203, 1939

Measurements with electro-acoustic devices demonstrated that earth pressures exerted by mechanically consolidated backfills of bridge abutments were considerably higher than those of unconsolidated fills. The measurements also showed an increase in friction between wall and soil.

Oien and Kjell

An Earth Pressure Cell for Use on Sheet Piles - Oslo Subway, Proceedings, Brussels Conference on Earth Pressure Problems, Vol. II, p. 118, Brussels, 1958

Instruments developed by the Norwegian Geotechnical Institute are described. Those instruments were used in measurements on a sheetpile structure for the Oslo Subway.

Ovesen, N. K.

Anchor Slabs, Calculation Methods and Model Tests,  
Danish Geotechnical Institute, Bulletin No. 16, Copenhagen 1964

The author gives a calculation method for the resistance and horizontal movement of anchor slabs (based on modifications of Brinch Hansen's earth pressure theory). The nondimensional design charts and design examples are supported by the results of tests on two-dimensional analogy models and on three-dimensional models in sand. Details of model testing and techniques are given.

Peck, R. B.

Earth Pressure Measurements in Open Cuts, Chicago Subway,  
ASCE Transactions, Vol. 108, pp. 1008-1036, 1943

Contains results of earth pressure measurements on several open cuts in soft and medium clay.

Peiner Kastenspundwand,

Ilse der Hütte, Peine, 3. Auflage 1960

This pamphlet gives the history of Peine piles and indicates structures for which they can be used. Included are tables of sections and section properties, corners and butts, and construction drawings.

Petermann, H.

Schrifttum über Bodenmechanik,  
Forschungsarbeiten aus dem Strassenwesen,  
Neue Folge Heft 10, Kirschbaumverlag, Bielefeld, 1953

Gives about 9000 references in soil mechanics and related fields.

Petermann, H. and W. Börner

Schrifttum über Bodenmechanik II,  
Forschungsarbeiten aus dem Strassenwesen,  
Heft 32, Kirschbaumverlag, Bielefeld, 1957

Gives about 4000 references in soil mechanics and related fields.

Petermann, H. and H. Kühn

Schrifttum über Bodenmechanik III,  
Forschungsarbeiten aus dem Strassenwesen,  
Heft 46, Kirschbaumverlag, Bielefeld, 1961

Gives about 5500 references in soil mechanics and related fields (period 1955-1960).

Petermann, H. and H. Kühn  
Schrifttum über Bodenmechanik IV,  
Forschungsarbeiten aus dem Strassenwesen,  
Band 63, Kirschbaumverlag, Bad Godesberg, 1965

Gives about 9000 references in soil mechanics and related fields (period between 1961-1964).

Piles, Horizontal Piles Brace Cofferdam Wall,  
Engineering News-Record, Vol. 160, No. 17, pp. 55-58,  
April 24, 1958

Horizontal H-piles were driven through a cofferdam and anchored to wales to act as a tie rod system for the high cofferdam wall.

Plummer, F. L. and S. J. Dore  
Soil Mechanics and Foundations,  
Pitman Publishing Corporation, New York, 1940

The text contains procedures for the design of retaining walls, active, passive and at rest pressures. Other articles included are: algebraic derivation of Coulomb's theory, graphic solution of Coulomb's theory, failure of retaining walls, application of Coulomb's theory, and design of sheet pile bulkheads.

Richart, Jr., F. E.  
Analysis for Sheet Pile Retaining Walls,  
ASCE Transactions, p. 1113, 1957

Sheet pile analysis method assuming the piling to be cut at the dredge line and all loads above this line transferred to the embedded pile portion which is treated as a beam on an elastic foundation.

Richart, Jr., F. E.  
Anchored Bulkhead Design by Numerical Method,  
ASCE Journal of the Soil Mechanics and Foundation  
Division, February 1960

A good review of classical design methods for anchored bulkheads and presentation of a new numerical method which is rapid and of practical value.

Romanoff, M.

Corrosion of Steel Pilings in Soils,  
National Bureau of Standards Monograph 58,  
U. S. Government Printing Office, Washington, D. C. 20025,  
October 1962

Results of inspections made on steel pilings which have been in service in various underground structures under a wide variety of soil conditions for periods of exposure up to 40 years are presented. In general, no appreciable corrosion of steel piling was found in undisturbed soil below the water table regardless of the soil types or soil properties encountered. Above the water table and in fill soils corrosion was found to be variable but not serious.

Rombas, Steel Sheet Piling,

Sidelor Usine de Rombas,  
Steel Sheet Piling Central Office, 2, Rue de Penthievre,  
Paris, 1964

This book includes the section properties with description of Larssen, Lackawanna, and Rombas piles. Discussions include information on the placing of anchorages, anchorage accessories, articulation, cappings, and on methods to resist corrosion. Another chapter contains procedures for analyzing and designing of sheet pile structures, as well as information about pile driving, lifting, guiding, handling, usage, and extraction. Case histories and discussions of many sheet pile constructions are given.

Rowe, P. W.

Anchored Sheet-Pile Walls,  
Proceedings of the Institution of Civil Engineers,  
Vol. I, pp. 27-70, London, January 1952

Experiments with fifteen models of flexible walls retaining cohesionless soils are described, in which the influence of surcharge, anchor level, anchor yield, dredge level, soil type and state, pile flexibility and distribution of soil pressure has been studied. As a result a simple chart is proposed for the design of all types of anchored pile, for use with the "free earth support" analysis.

Rowe, P. W.

A Stress-Strain Theory for Cohesionless Soil with  
Applications to Earth Pressures at Rest and Moving Walls,  
Geotechnique, Vol. IV, No. 2, London, June 1954

The author discusses different earth pressure theories and their application to practical problems.

Rowe, P. W.

Sheet-Pile Walls at Failure,  
Proceedings of the Institution of Civil Engineers,  
Vol. 5, No. 3, pp. 276-315, Paper No. 6107, London, May 1956

Correspondence on the above "Sheet-Pile Walls at Failure"  
is given in the Proceedings of the Institution of Civil  
Engineers, Vol. 6, p. 347, London, February 1957

Experiments are described with model walls in loose sand  
where the walls failed in bending or penetration. The  
results are compared with Brinch Hansen's limit design method and  
the Author's flexibility method, and indicate that either method  
may be used as an initial basis for limit design. Modified soil  
constants may be necessary for use in Brinch Hansen's method with  
compressible subsoils. The principles of the method are compared  
with the flexibility method and the latter is shown to be of  
general application to subsoils of all compressibilities.

Rowe, P. W.

Measurements on Sheet Pile Walls Driven into Clay,  
Proceedings, Brussels Conference on Earth Pressure  
Problems, Vol. II, p. 127, Brussels, 1958

Graphs provide simple basis for design of sheet pile  
walls in clay; this method is based on dimensionless  
stability numbers and relative stiffness numbers.

Rowe, P. W. and A. Briggs

Measurement on Model Strutted Sheet Pile Excavations,  
Proceedings, 5th International Conference on Soil  
Mechanics and Foundation Engineering, Vol. II,  
pp. 473-478, Paris, 1961

The authors show the need to differentiate between  
deformation and failure problems in strutted sheet  
pile analyses. If several struts are used, then  
the actual load may not be computed on the basis  
of the failure parameters of the soil.

Schenck, W.

Rammen und Ziehen,  
Grundbau-Taschenbuch, Band 1, 2. Auflage, pp. 716-765  
Wilh. Ernst & Sohn, Berlin, 1966

This reference gives descriptions of German driving  
and extraction devices, appropriate rigs and driving  
measures under special conditions.

Schneebeli, G. and R. Cavaillé-Coll

Contribution au Calcul de la Stabilité des  
Batârdeaux à Double Paroi de Palphanches  
(Contribution to the Stability Analysis of Double-Wall  
Sheet Pile Cofferdams),  
Proceedings, 4th International Conference on Soil  
Mechanics and Foundation Engineering, Vol. II, p. 233,  
London, 1957

This paper studies cofferdams built on rock and consisting of two straight walls of sheet piling with a sand-fill as far as their security from overturning is concerned. A new formula is proposed which gives the maximum overturning moment corresponding to the resistance of sand-fill.

Schultze, E.

Vergleich von Berechnungsverfahren für verankerte Spundwände,  
Der Bauingenieur 33, Heft 4, pp. 163-167, 1958

Based on the Princeton University Master's Thesis by Gibbons and Jasper (1954), this reference gives comparisons of calculation procedures developed by Blum, Tschebotarioff, Rowe, Skempton and the Danish Rules. Included are the results of two examples (cohesive and granular soil).

Schultze, E.

Empfehlungen für die Berechnung von Spundwänden in  
der Deutschen Bundesrepublik,  
Proceedings, International Conference on Soil Mechanics  
and Foundation Engineering, p. 87093, Budapest, 1963

A brief review of the development in Germany of a simple and economical method of dimensioning bulkheads, based on tests performed by Rowe. It is suggested that the method has a good application in simple cases, while the methods developed by Rowe or Brinch Hansen are recommended in more complicated cases.

Seelye, E. E.

Foundation, Design, and Practice,  
John Wiley & Sons, Inc., New York, 1956

Practical approach to design problems with sections devoted to: Rankine's and Coulomb's solution to earth pressure, bulkheads and relieving platforms, sheet pile bulkheads, pile anchorages and deadman, tie rod stresses, and selection of retaining walls.

Sheet Piles: How to Work with Sheetpiles,  
Construction Methods and Equipment, November 1962

This reference outlines the practical fundamentals of working with steel sheetpiling, i.e. pile setting, bracing, hammer selection, extraction, jetting, splicing, cutting, selection of pile type for cofferdams, tips on driving. A useful field guide.

Sheet Piles: How to Work with Sheetpiles,  
Construction Methods and Equipment, pp. 92-95, December 1962

Summary and illustrations of the applications and practical limitations of bracing systems for cofferdams of interlocking steel sheet piling, i. e. crosslot bracing, raker or inclined bracing, arcs supported by struts, internal ribs functioning as compression rings.

Sheet Piles: How to Work with Sheetpiles,  
Construction Methods and Equipment, pp. 102-105, January 1963

Review of construction procedures for cellular cofferdams and straight-wall earth fill structures with or without tie rods. Cofferdam cell sizes should be standardized on large jobs and liberal dimensions are recommended. Construction and use of driving templates are detailed.

Sheetpiling, Huge Guide-Traveler Speeds Driving of 65 Miles of Sheetpiling,  
Engineering News Record, Vol. 143, No. 19, pp. 39-41, November 1949

Pile driver was placed on rails to drive 7400 piles at Bethlehem Steel Sparrows Point Plant. The article includes positioning of driver, cycle of driving, guiding of piles, preparation and driving cell ends. It shows illustration of the system of trolley hammers and gives a progress report of method and job.

Shinohara, T., T. Tateishi and S. Kitajima  
Lateral Resistance of Sheet Pile Cellular Detached Pier at Shimizu Harbour,  
Soil and Foundation, Vol. I, No. 1, pp. 35-41, April 1960

The results of a full scale lateral load test on a cellular steel sheetpile wall in soft clay with a maximum load of 100 tons. Measurements of lateral displacements and tilting are recorded.

Sowers, G. F., A. D. Robb, C. H. Mullis, and A. J. Glenn

The Residual Lateral Pressures Produced by Compacting Soils, Proceedings, 4th International Conference on Soil Mechanics and Foundation Engineering, Vol. II, p. 243, London, 1957

The lateral pressures developed by soil compactions which remain after the compaction has been completed have sometimes produced excessive deflections in earth-retaining structures. Results of laboratory and field tests are reported.

Spangler, M. G.

Horizontal Pressures on Retaining Walls due to Concentrated Surface Loads, Iowa Engineering Experiment Station, Bulletin 140, Iowa City, Iowa

Intensity and distribution of the lateral pressure due to concentrated surface loads were determined experimentally. The author used as a backfill material pit run gravel with 13% particles passing the 200-mesh sieve. The lateral support consisted of a reinforced cantilever wall, 84 in. high and 6 in. thick, which was free to tilt about the outer edge of the base plate.

Stüdemann, G.

Korrosionsschutzmassnahmen bei Stahlspundwänden, Die Bautechnik 43, pp. 329-338, 1966

A list of economical aspects is given for the selection of measures to protect steel sheet piles against corrosion. The compared measures are: painting, metallizing, cathodic protection, increasing the cross-sectional area or choice of a higher grade of steel than necessary from the structural analysis. Only those sheet pile walls are compared which are no longer accessible after installation.

Swiger, W. F.

Prestressed Sheet Pile Underpinning, ASCE, Civil Engineering, June 1957

Horizontal struts pre-jacked against wall to prevent it from yielding which could cause settlement of adjacent power plant. Interesting stages described in some detail.



Teng, W. C.

Foundation Design,  
Prentice Hall, Inc., Englewood Cliffs, N. J., 1965

Parts of this book deal with pile driving devices, types of sheet piling walls, the design of cantilever and anchored bulkheads using different methods, tie rods and anchorages and design of braced and cellular cofferdams. Good design examples are also given.

Terzaghi, K.

Anchored Bulkheads,  
Purdue Conference on Soil Mechanics,  
pp. 259-269, September 1940

The article defines anchored bulkheads with assumptions stated prior to design. Methods are stated for finding the earth pressure; method of analysis, method of final design and pile selection.

Terzaghi, K.

Theoretical Soil Mechanics,  
John Wiley and Sons, New York, 1943

Chapter XI gives theories for analysis of anchored bulkheads with and without fixed earth support. Fixed support is analyzed graphically by elastic line and equivalent beam method. Also computation methods are given for bulkhead anchorages by means of batter piles, anchor walls, and anchor plates.

Terzaghi, K.

Anchored Bulkheads,  
ASCE Transactions, Vol. 119, pp. 1243-1280,  
with discussion, pp. 1281-1324, 1954

A comprehensive evaluation of bulkhead design methods including observations of the forces; the effect of wall movements, wall friction, unbalanced water pressure, line loads and point loads on the magnitude and distribution of the earth pressure; the influence of flexural rigidity on bending moments; anchor pull studies; determination of sheet pile depth and maximum bending moment. Review of safety requirements in bulkhead design. Many charts and methods.

Thompson, P. J. and M. A. J. Matich

The Performance of Some Steel Sheet Pile Bulkheads,  
Proceedings, 15th Canadian Soil Mechanics Conference,  
pp. 80-114, 1961

Slope indicator measurements on members of different bulkheads have been analyzed and compared with theoretical predictions. Emphasis on evaluating the effective section modulus of sheet pile walls by taking account of friction in the interlocks. Details of the Wilson slope indicator and its applications are presented.

Tschebotarioff, G. P.

Soil Mechanics, Foundations, and Earth Structures,  
McGraw-Hill, New York, 1953

Chapter 16 reviews and compares five popular methods of sheet pile design and proposes a bulkhead design procedure based on field observations and laboratory testing - the simplified equivalent beam method.

Tschebotarioff, G. P. and E.R. Ward

Measurements with Wiegmann Inclinator on Five Sheet Pile Bulkheads,  
Proceedings, 4th International Conference on Soil Mechanics and Foundation Engineering, Vol. II, p. 248, London, 1957

This paper describes five bulkheads in the harbours of New York, Galveston, Baltimore, and Cleveland on which measurements were performed with the Wiegmann Inclinator. Bending moments thus determined in the steel sheet piling of these bulkheads are compared with moments computed by two of the existing theories.

Tschebotarioff, G. P.

Certain Features of Lateral Pressure of Soil,  
Highway Research Board, Special Report No. 60,  
pp. 154-162, Washington, D. C., 1960

This reference gives general informations about forces in braced cuts with inclined struts and compares four designing methods for anchored sheetpile bulkheads.

Tschebotarioff, G. P.

Design and Construction of Flexible Retaining Structures,  
Proceedings, Soil Mechanics Lecture Series on Design of  
Structures to Resist Earth Pressures, pp. 35-48,  
Chicago, 1964

A review of recent trends in both design and construction including new types of sheet piling both in the U. S. and Europe. Case histories of several structures are briefly described and the cause of failure is examined. An example is given for corrosion at a depth while the steel surface was still fresh near the water surface.

Verdeyen and Roisin

Relationships between External Concentrated Load Effects and the Characteristics of Flexible Bulkheads (in French)  
Proceedings, 5th International Conference on Soil Mechanics and Foundation Engineering, Vol. II, p. 501, Paris, 1961

Study of the free earth support case with a concentrated load somewhere at the top. Influence of distance from the edge. Requires changes of conventional theories.

White, A., J. A. Cheney and C. M. Duke

Field Study of Cellular Bulkheads,  
ASCE Journal of the Soil Mechanics and Foundation  
Division, Vol. 87, No. SM4, pp. 89-124, August 1961

Detailed field observations of a cellular bulkhead in Long Beach Harbour. Discussion of hoop tensions, lateral earth pressures, sheet distortion, field instrumentation and construction procedures.

White, E. E.

Design and Construction of Braced Cuts,  
Proceedings, Soil Mechanics Lecture Series on Design  
of Structures to Resist Earth Pressures, pp. 93-127,  
Chicago, 1964

This reference gives an informative commentary of numerous methods used to design and construct bracings for excavations in difficult situations. Empirical methods are compared with theoretical equations, and documented by several clearly described case histories. Methods discussed include interior and exterior bracing, tie back walls, and slurry trenches.

Wiegel, R. L. and R. E. Skjei  
Breaking Wave Force Prediction,  
Proceedings, ASCE, Waterways and Harbors Division,  
Vol. 84, pp. 1-14, March 1958

Laboratory data of the kinematics of waves breaking  
on a model beach are presented and analyzed for force  
and velocity.

Windels, R.  
Berechnung von Bohlwerken nach dem Traglastverfahren,  
Die Bautechnik 36, Heft 6, pp. 212-220, 1959

An ultimate load method is derived for the design of sheet  
piling bulkheads. For the general case of variable cross-  
section and variable normal force a graphical solution is  
worked out. For constant cross-section and constant  
normal forces nomograms are given for different types of  
supports. No redistribution of earth pressure is  
considered.

Wrigley, G. A.  
Some Lessons for British Practice?  
Civil Engineering and Public Works Review,  
pp. 1422-1425, November 1963

Description of tidal water deep draft berth construction  
techniques at Hamburg with particular reference to the  
development of steel sheet pile walls driven in a  
concertina pattern forming a deep composite wall with  
greatly increased section modulus. Higher driving costs  
result but these are offset by the improved utilization  
of plain sheet pile sections. All designs are of the  
relieving platform type and the steel sheet piling is  
provided with vent holes to permit free movement of water.  
Useful in practice.

Zweck, H. and Th. Dietrich  
Die Berechnung verankerter Spundwände in nichtbindigen  
Böden nach Rowe,  
Mitteilungsblatt der Bundesanstalt für Wasserbau,  
Karlsruhe, Heft 13, 1959

This reference gives a description and interpretation  
of Rowe's theory. Design tables are included, by  
which the iterative calculation necessary in Rowe's  
method can be reduced.

6. AUTHOR INDEX

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## 7. ACKNOWLEDGMENTS

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